United Nations
Economic Commission for Africa

Volunteered Geographic Information in Africa

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Preface

Volunteered Geographic Information (VGI) has proven to be a well-balanced method of collecting geospatial information as opposed to the authoritative method employed by government agencies and private industry. There is an upsurge in terms of the number of people contributing in web-based social networking sites and contributing volunteered geographic data.

VGI provides new perspectives for computational geography, VGI expresses itself as a transformed Geographic Information System (GIS), based on the use of data-intensive computing and simulations to uncover the underlying mechanisms behind geographic forms and processes. GIS has been criticized for its persistence on a single point of view. VGI, through its participatory approach, allows individuals to assert their own understanding of their surroundings thereby playing an essential part in local decision-making. Also, GIS has been criticized for its tendency to empower those who can pay for its high costs while side lining those who cannot. Therefore, by engaging citizens in the practice of obtaining and using geographic information, VGI has the potential to change this landscape profoundly and even eliminate some of this criticism.

Africa is presently confronted by major challenges including, but not limited to, climate change, disaster risk, food security, water scarcity, energy shortage, health-related problems and environmental stresses and food crises. These issues affect citizens, businesses and the community at large. In order to address these issues, efforts are being made by the Economic Commission for Africa (ECA) to support African countries to work out strategies and policies to tackle the challenges in various sectors of development.

ECA has been mandated to enhance the knowledgebase needed to strengthen human and institutional capacities aimed at supporting sound policies in member states. ECA is assisting member states to frame and harmonize national policies in various segments of geo-information. ECA supports member states in their efforts in formulating geospatial policies and strategies for the development and implementation of National Spatial Data Infrastructures (NSDI). ECA is also leading the Global Geospatial Information Management (GGIM) initiative in Africa, in order to guarantee that GGIM adequately reflects African issues and shape its direction and dimension in addressing geospatial governance in Africa.

Volunteered Geographic Information (VGI) is part of the vision of ECA on geo-information aimed at fostering the use of spatial data and other information products that permeates every aspect of society and making spatial information available to people who need it, when they need it, and in a form that they can use to make decisions with minimal pre-processing.

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Abbreviations and Acronyms

ACID	Atomicity, Consistency, Isolation, Durability
API	Application Programming Interface
CKW	Community Knowledge Workers
CODIST	Committee on Development Information, Science and Technology
DBMS	Database Management System
ECA	Economic Commission for Africa
EXIF	Exchangeable Image File Format
FOSS	Free and Open-Source Software
GFDRR	Global Facility for Disaster Reduction and Recovery
GGIM	Global Geospatial Information Management
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Geographic Positioning System
HIU	Humanitarian Information Unit
HOT	Humanitarian OpenStreetMap Team
INASAFE	Indonesia Scenario Assessment for Emergencies
ITU	International Telecommunication Union
NASA	National Aeronautics and Space Administration
NSDI	National Spatial Data Infrastructures
NMA	National Mapping Agency
OGC	Open Geospatial Consortium
OSM	OpenStreetMap
REST	Representational State Transfer
SD	Secure Digital
SDI	Spatial Data Infrastructure
SFTP	Secure File Transport Protocol
SMS	Short Message Service
SOA	Service-Oriented Architecture
SQL	Structured Query Language
UGC	User Generated Content
UNHCR	United Nations High Commissioner for Refugees

UNITAR	United Nations Institute for Training and Research
UNOSAT	UNITAR Operational Satellite Applications Programme
USB	Universal Serial Bus
USSD	Unstructured Supplementary Service Data
VGI	Volunteer Geographic Information
WKB	Well Known Binary
WKT	Well Known Text
WWW	World Wide Web

I. Chapter One

Introduction

A. Overview of VGI concept

One of the most important aspects in Web 2.0 development is the emergence of crowd sourced information. Crowdsourcing is the practice that allows a large group of users to perform functions that were difficult to automate or expensive to implement. Crowdsourcing can be used in large-scale community activities that were difficult to implement before Web 2.0. Such community activities recently focused on the collection of information. One of the most successful crowdsourcing examples is wikipedia, the free online encyclopedia. Wikipedia is written collaboratively by largely anonymous volunteers (Haklay, 2013).

The potential for crowdsourcing geographic information has also captured the attention of researchers in the geospatial field. Goodchild described this activity as Volunteered Geographic Information (VGI) [(Goodchild, 2007). Information created by citizens is generally called user-generated content, and specifically the geographic information is known as Volunteered Geographic Information (VGI). Volunteered Geographic Information is digital spatial data collected voluntarily by citizens rather than by formal data producers [(Goodchild, 2007), (Sun, 2011).

Web 2.0 technology, which enables a user to create their own content and to edit content created by others, is the technology behind User-Generated Content (UGC). And so the VGI is based on the wiki technology, or Web 2.0 technology. Web 1.0 technology is one directional, where users only retrieve or download information from web pages. Contrary to Web 1.0, Web 2.0 technology is bi-directional, allowing users to collaborate and share common information with each other via the Internet. Thus, users of VGI could upload their own geographic information to a web server, download the geographic information shared by others, and even edit the geographic information created by others (Jia, 2010).

Goodchild described user-generated content in the web as "a remarkable phenomenon ... (that) has become evident in recent months: the widespread engagement of large numbers of private citizens, often with little in the way of formal qualifications, in the creation of geographic information, a function that for centuries has been reserved to official agencies. They are largely untrained and their actions are almost always voluntary, and the results may or may not be accurate. But, collectively, they represent a dramatic innovation that will certainly have a profound impact on geographic information systems (GIS) and more generally on the discipline of geography and its relationship to the general public. I term this volunteered geographic information (VGI), a special case of the more general web phenomenon of user-generated content ..." (Goodchild, 2007).

The way geographic data is collected at an individual basis is different from the traditional way by national mapping agencies. The use of Global Positioning System (GPS) allows untrained users to automatically acquire their location accurately, facilitating gathering high accuracy geographic information. GPS can be accessed by the use of different devices such as cameras and mobile phones so that the information collected using these devices can be automatically tagged with their geographic coordinates. So far, a huge amount of geographic data has been collected due to the increasing number of contributors and volunteers.

B. The varying role of geo-information within the VGI environment

The present age has considerably altered mapping and the dreams of cartographers have increasingly been realized. Technological innovation through the use of numerical maps for decision-making have transformed the way of doing business in areas including, but not limited to, government planning, emergency response, statistical analysis, automated navigation and business delivery domains. It's common knowledge that geospatial information is a vital component of decision-making within the private and government sectors. Today, most African countries promote decentralization, thus giving to the local communities significant attention and power in decision-making, which impacts economic development at all levels. VGI and other emerging applications have brought spatial data application to the forefront in everyday activities in the lives of people. The authority of mapping agencies as the exclusive provider of spatial information has gradually been eroded by the spatial data revolution the African continent is presently experiencing. Mobile and other devices are generating big spatial data at an alarming rate, making it an imperative for the geospatial community to seek ways and methods of harnessing the potential of the data being harvested.

The present steady departure from official geospatial data to crowdsourcing has been driven by the fact that government machinery to produce spatial information is slow as most mapping agencies follow rigorous extended methodologies and processes for producing spatial data. The authoritative data produced by mapping agencies has been the backbone for the spatial data revolution as most fundamental data sets have been developed over the years by these agencies. It is vital also to note that the different government gazettes were limited in scope and failed to cover a wide range of features as compared to the present data being harvested through crowdsourcing. Equally, delays in the production of data by mapping agencies have led to lags in decision-making thereby creating a vacuum that is being filled by crowedsourced data.

The present urge to incorporate unofficial with official spatial data is unresolved and essential mechanisms should be put in place to enable an effective merging process within the African continent. There is also the need for developing regional and continental spatial data outsourcing platforms for end users to actively generate the desired spatial data. This spatial data generated by the public will eventually be used to update government or official data sets, thereby drastically reducing cost as well as facilitating the production of real-time spatial data for prompt decision-making.

It should be stressed that there is an information gap concerning spatial data, which requires the use of new methods and innovations to reduce it. Governmental services should be involved in this spatial data revolution process so as to ensure that quality control regulatory measures are put in place for use by the various actors. The focus should be on regulating the end users and assimilating them into all the stages involved in crowdsourcing. Crowdsourcing of data should not be limited to digital technology as traditional mapping methods have been found essential in mapping areas out of reach in terms of Internet connectivity, mobile network coverage and other technological innovations.

Though crowdsourcing will not fill the spatial information gap, it should be accepted that its role is fundamental in reducing the spatial data gap in an ever-evolving world. Since individuals with different educational levels as well as non-geospatial professionals are involved in the crowdsourcing process, the trustworthiness of the harvested data is often questioned, therefore, there is need to link the generated data to official data sets for authentication before usage. In order to limit user fatigue in generating spatial data, policies have to be developed for organizing user-end projects that will keep them engaged in developing the needed data. The mapping agencies should come up with regulations that create a dedicated internal regulated process for generating crowdsourced data.

A good way for quality assuring information is to develop in-built mechanisms for tracking uploads, changes and deletions of data. This mechanism should be entrusted to the crowd that self-regulates the maintenance and accuracy of data. The participants involved in the data harvesting process should be compensated with tangible items such as data downloads, points, cash, etc. or intangible things such as communication rewards like being given a chance to respond to social media commentary. This enhance the building of community cohesion, improve information for end user work requirements as well as chance personal or group satisfaction. No matter what it is, the feedback must be something valued by the target contributor community to ensure their initial or ongoing engagement with the crowdsourcing programme (UNO, 2012).

The documented outcomes of the Broadband and Youth Networking Dialogues (BYND) 2015 Global Youth Summit, held 9-11 September 2013 in Costa Rica, has been identified as the first-ever official United Nations documented declaration on crowdsourcing. This youth summit organized by the International Telecommunication Union (ITU) called on member states to promote the use of technology for the harvesting of data aimed at promoting societal wellbeing. The final set of priorities, crowdsourced using Crowdicity, was delivered to the United Nations General Assembly by the President of Costa Rica, Laura Chinchilla. It was then granted official status by Ban Ki-moon, marking a significant shift in the way the United Nations is driving global discussion and harnessing external views (ITU, 2013).

With the development of Web 2.0 and mobile devices improvement to provide data related to their location, people began to be more involved in Volunteered Geographic Information (VGI), providing data and information that are in many cases more detailed and of a higher quality than those provided by official institutions (Horita and others, 2013). In the past few years, there has been rapid growth of interest in VGI (Goodchild, 2007). It has proven successful as a means of acquiring timely and detailed geographic information at very low cost, though it suffers from lack of quality assurance (Li, 2012).

The last decade has also seen a revolutionary development where many service providers have started providing local and global—most notably Google Inc. In some applications, maps can be worked on by individuals, collectives and communities, enabling them to place information on base maps and utilize the power of mapping technologies for analysis and presentation. Individuals could create their own digital geographic information in the form of high-quality, on-line maps, essentially at no cost. For instance, the Google Maps Application Programming Interface (API) is a way to organize information on maps, both manually and programmatically. Google Earth is also used for innovative community mapping with significant utility for civil society.

C. VGI, crowdsourcing, citizen science and neogeography

According to (Van den Berg, 2011), there are differences and similarities between VGI, crowdsourcing, citizen science and neogeography. To better comprehend these concepts, some definition of terms are required:

1. New media

Content available on-demand through the Internet, accessible on any digital device, usually containing interactive user feedback and creative participation [Wikipedia][1]

2. User-generated content

Denoting or relating to material on a website that is voluntarily contributed by members of the public who use the site [Oxford][2]

3. Volunteered geographical information (VGI)

Volunteered Geographic information (VGI), a georeferenced type of citizen science, is a growing area of information gathering. The term was coined by geographer Michael F. Goodchild who, in exploring the world of user-generated content on the web, noted that "a remarkable phenomenon ... has become evident in recent months: the widespread engagement of large numbers of private citizens, often with little in the way of formal qualifications, in the creation of geographic information, a function that for centuries has been reserved to official agencies. They are largely untrained and their actions are almost always voluntary, and the results may or may not be accurate. But, collectively, they represent a dramatic innovation that will certainly have profound impacts on geographic information systems (GIS) and more generally on the discipline of geography and its relationship to the general public. I term this volunteered geographic information (VGI), a special case of the more general Web phenomenon of user-generated content ..." (Goodchild 2008).

User-generated content with geospatial components

User-generated content, and its subset, volunteered geographic information, covers a span of geographically-based initiatives and abilities, including such novel applications as Wikipedia, Wikimapia, Flickr, OpenStreetMap, and the overall concept of web mashups (overlaying disparate data and existing maps to produce a new map). As Goodchild (2008) states: "These are just a few examples of a phenomenon that has taken the world of geographic information by storm and has the potential to redefine the traditional roles of mapping agencies and companies" (Klinkenberg, 2015).

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[1] Manovich, Lev. "New Media From Borges to HTML." The New Media Reader. Ed. Noah Wardrip-Fruin & Nick Montfort. Cambridge, Massachusetts, 2003. 13-25. ISBN 0-262-23227-8 and Dimmick, J., Chen, Y., & Li, Z. (2004). Competition between the internet and traditional news media: The gratification-opportunities niche dimension. Journal of Media Economics. Link (https://en.wikipedia.org/wiki/New_media

2 http://www.oxfordlearnersdictionaries.com/definition/english/user-generated

4. Crowdsource

Obtain (information or input into a particular task or project) by enlisting the services of a large number of people, either paid or unpaid, typically via the Internet [Oxford][3]

5. Citizen science

The collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists [Oxford][4]

6. Neo-

A new or revived form of [Oxford][5]

7. Geography

The study of the physical features of the earth and its atmosphere, and of human activity as it affects and is affected by these, including the distribution of populations and resources and political and economic activities [Oxford][6]

8. Neogeography

Use of GIS, web mapping and Global Navigation Satellite System (GNSS) by anyone; innovative colloquial applications, even absurd ones; ad hoc mapping; collaborative mapping and VGI; open data repositories; geo-tagging; mashups; relative vs absolute quality; virtual land art; unconventional uses; psychogeography; critical GIS (social theory, social justice, feminism, power relationships, epistemology, manipulation, ethnography, etc.); qualitative applications; ethical issues (privacy, surveillance).

D. Differences and similarities between VGI, crowdsourcing, citizen science and neogeography

1. VGI and crowdsourcing

The integration between VGI and crowdsourcing has been demonstrated in applications such as blogs, activity tracker, Peckham's and Peace Wall. Other Crowdsourcing applications have been linked with VGI and examples include Amazon Mechanical Turk, Foldit Online Protein, Puzzle, SETI@Home, Indiegogo, Kiva Microfunds, Oxford English Dictionary Reading Programme and America's Funniest Home Videos. Examples have been noted where there is a link between VGI and crowdsourcing in applications such as HarassMap, Tracks4Africa, OpenStreetMap mapping party, 2nd South African Bird Atlas Project (SABAP2), Blue and Green Drop Project, Cemetery recording projects, real-time traffic monitoring, Brown Moses, Google Flu Trends and Involuntary VGI.

[3] https://en.oxforddictionaries.com/definition/crowdsource
[4] https://en.oxforddictionaries.com/definition/citizen_science
[5] https://en.oxforddictionaries.com/definition/us/neo-
[6] https://en.oxforddictionaries.com/definition/geography

2. VGI and citizen science

The merging of VGI and citizen science is being conducted in applications such as Tracks4Africa, OpenStreetMap, Real-time traffic monitoring, Brown Moses, Arab Spring and Cyber-bullying. Equally, citizen science has integrated VGI in applications such as Foldit Online Protein, Puzzle, SETI@Home, Amateur Astronomer, Zooniverse: Planet and Hunters. The link between VGI and citizen science has been identified in applications such as Mappiness, WideNoise, 2nd South African Bird Atlas Project (SABAP2), Household Consumption Diary, Christmas Bird Count, Lost Ladybug Project, eBird Project and Old Weather.

3. VGI and neogeography

In the application process of VGI, components of neogeography have been incorporated and examples include: Christmas Bird Count, Sketch of Direction and Counter-mapping. In carrying out neogeography, components of VGI have been built-in in applications such as: Mashup of Web Services and critical GIS and personal navigation. The intersection between VGI and neogeography has been noticed in applications such as: Ushahidi, FrontlineSMS, PPGIS, ABCD, Transparency and Accountability, Empower Communities, Brown Moses, Virtual Land Art, Cyber-bullying, Arab Spring and crisis mapping applications.

4. Crowdsourcing and citizen science

Crowdsourced data has included citizen science in applications such as Amazon Mechanical Turk, Wikipedia, Brown Moses, Indiegogo, Trial by Jury, America’s Funniest Home Videos and Kiva Microfunds. Examples where citizen science has used crowdsourcing have been demonstrated in personal fossil collection, personal weather station and amateur astronomy applications. The intersection between crowdsourcing and citizen science has been seen in applications such as Plant Watch, SETI@Home, Longitude Prize, Voyages Bio Sous-Marine, Belly Button Biodiversity Project, Foldit Online Protein Puzzle, Zooniverse: Planet Hunters, Oxford English Dictionary Reading Programme, Eskom Expo for Young Scientists, InnoCentive and Old Weather.

5. Crowdsourcing and neogeography

Crowdsourcing has been integrated with neogeography in applications such as Foldit Online Protein Puzzle, Zooniverse: Planet Hunters, Amazon Mechanical Turk, Traditional Census, Kiva Microfunds, Indiegogo, SETI@Home, Longitude Prize, Oxford English Dictionary Reading Programme and America’s Funniest Home Videos. Equally, neogeography applications have used crowdsourcing through the use of personal navigation, Flâneur, critical GIS and deep topography. The intersection between crowdsourcing and neogeography has been demonstrated in Ushahidi, FrontlineSMS, crisis mapping and Brown Moses.

6. Citizen science and neogeography

Citizen science has used neogeography in applications such as Foldit Online Protein Puzzle, Zooniverse: Planet Hunters, SETI@Home, Longitude Prize, Christmas Bird Count and amateur astronomy applications. Neogeography has included citizen science in applications such as Flâneur, Transparency and Accountability, Brown Moses, Virtual Land Art, critical GIS, Cyber-bullying and personal navigation applications. The combination of citizen science and neogeography has been noticed in WideNoise, Mappiness, and 2nd South African Bird Atlas Project (SABAP2) as well as in Psyche and Place (Cooper AK., 2012).

E. Authorship or ownership: what counts the most in participatory mapmaking processes?

Authoritative maps are mostly produced by national mapping authorities and collaborative maps are produced (online) by usually dispersed individuals sharing a common objective or problem; this is known as Volunteered Geographic Information—(VGI). Participatory maps are produced by people having a common purpose, sharing a pool of knowledge, kinship, space and resources on a given territory; and usually working together (physically) when generating the data or making the map. It is important to determine if the collective map-making processes (of VGI) erases individual responsibilities as well as authorship or ownership. The table below attempts to answer these and other questions.

F. Significance of VGI in community mapping

Engaging communities in creating maps of the features in their landscape is vital for them. These communities include: individual citizens, businesses, villages, government departments etc. Assembling all available maps in the community into a shareable spatial data warehouse is imperative as sharing through the Internet and other modes leads to effective management of community resources. VGI helps communities to develop web-based mapping applications to engage and plan community activities. Communities should be able to develop web applications aimed at encouraging VGI activities, developing partnerships aimed at prioritizing community needs and manage resources such as creative rural economy, culture and heritage, tourism, buying local products, promoting businesses, etc. as well as developing sustainability models in community management. Equally, communities can develop mapping applications, design databases to promote activities, edit views and public view content as well as share VGI contents such as photos, videos, stories, etc.

Who	*Participatory mapping*	*Collaborative mapping (online) (VGI)*
Knowledge holders	Nominated by community(ies)	Volunteers
Technology Intermediary	Personally known and trusted	Known by face value (brand)
Primary users	Participants and the communities they represent	Wider public, aid agencies, government, technology intermediaries
Why	Participatory mapping	Collaborative mapping (online) (VGI)
Motivation	Addressing personal / community problems and aspirations	Responding to calls for mobilisation and / or the desire to share timely information
Purpose of mapmaking	Set by the knowledge holders	Set by the intermediaries or catalysts
What	Participatory mapping	Collaborative mapping (online) (VGI)
Knowledge shared	Complex, articulated	Specific, timely, observations
Data	Contiguous and sequential	granular
Issues (level)	Local	Local, regional and international
Who does what?	Participatory mapping	Collaborative mapping (online) (VGI)
Data input	Participants	Contributors
Data analysis	Participants and trusted technology intermediaries	Delegated to third parties
Data validation	Participants and trusted technology intermediaries	System editors, third parties and other users
Follow-up action incl. advocacy	Knowledge holders	Third parties
Knowledge holders and data users	Same / connected	Diverse / loosely connected / disconnected
How	Participatory mapping	Collaborative mapping (online) (VGI)
Interface	Mainly physical	Mainly virtual, computers, mobile devices
Interaction	Face to face	Remote, in cyberspace
Data input	Articulated, based on face to face interactions	Mouse click / SMS
Control of data sharing by knowledge holders	High (when good practice is in place)	Limited
Where	Participatory mapping	Collaborative mapping (online) (VGI)
Geographical scope	Limited	Unlimited (zoom in / out)
Scale	> 1:15,000	Any scale (zoom in / out)
Informants	At venue	Dispersed
In the process	Participatory mapping	Collaborative mapping (online) (VGI)
Action type	Participation	Contribution

Focus on	Generating data	Viewing data
Learning while inputting data	High	Low
Learning from output	High	High
Responsibility	High	Low, anonymity is allowed
Potential consequences	Immediate	Distant / unknown / unaware
Trust	In people	In the technology and in the brand
Time to implement	Long	Short
Transparency	High in good practice	Depending on “Terms and Conditions”
Main considerations	Participatory mapping	Collaborative mapping (online) (VGI)
Most valued	The process	The outputs
Authorship	With participants	Scattered , undefined
Intellectual ownership	Collegial by knowledge holders / community(ies)	Owner of platforms, as per “Terms and Conditions”
Accountability	High	Low, anonymity is allowed
Self-realization	High	Low
Identity building	High	Low
Satisfaction	High (challenge)	High (for contribution)
Impact on public opinion	Low (high if channelled via the Internet)	High

Source: Presentation 'Authorship or ownership: what counts the most in participatory mapmaking processes?' by Giacomo Rambaldi at Symposium The Future of PGIS: Learning from Practice? ITC-University of Twente, 26 June 2013, CTA, Netherlands, pgis.cta.int, ppgis.net, iapad.org

The pros of VGI are that communities can access base map layers, imagery and other thematic layers from line departments or ministries. Collaborative development and data access are primordial for community planning and development as communities can develop models for governance for business sustainability.

Creating awareness at the citizen and municipal levels is equally essential as VGI facilitates the engagement of the local private sector by bringing forth new ideas as well as the development of methods for sharing geographic information. Within a community, VGI broadens technical expertise for the development of thematic maps from sources including, but not limited to, Light Detection And Ranging (LiDAR), micro-climate networks, etc. VGI application at community level will facilitate the development and access to open government policies, capacity-building and will create a collaborative spirit, focusing on regional geography, certain thematic layers and developing community understanding by resolving conflicts, etc. This new available tool is essential for development platforms for cloud computing, facilitating data access, etc.

The challenges in developing a community VGI remain retraining, retooling and technology transfer among community members. The benefits are numerous within the community and these include: learning new technologies, sharing technology, building new ideas for community engagement, collecting data and using it several times, building community information archives and new products or tools for the market.

G. VGI Applications

VGI as a web-mapping application tool has been adopted and implemented by national mapping agencies (NMAs) in areas including, but not limited to, fundamental and thematic data sets. The various types of VGI that provide information and data should be identified by NMAs. Traditionally, NMAs deal with topographic and cartographic maps and government departments generate thematic maps. The different layers of spatial data sets required for the implementation of VGI should be identified as a first step by NMAs before integration strategies and action plans are developed. The various VGI incorporation processes usually identify priorities for updating data, establishing the mapping scale, ground truthing, attribute accuracy, accuracy level and sustainability of the process, addressing conflicts, data access, quality assurance, crowdsourcing, feedback and accountability. Harmonizing VGI with NMA activities is urgent as VGI data is increasingly being generated and the services are swelling as VGI cost is low, it’s quick and sharing of data and services is flexible.

In the last few years, a lot of effort has been exerted in developing community-mapping methods to capture and analyse a large amount of data in a systematic way. By 2004, it had become evident that individuals could create their own digital geographic information in the form of high-quality, online maps, essentially at no cost. Websites such as Wikimapia and OpenStreetMap use web-based “crowdsourcing” technologies, which outsource tasks to a large group of web users to collect data, identify problems and innovate solutions to problems using VGI. Collaborative web-based efforts like OpenStreetMap, Google Map Maker, etc., enable experts and amateur enthusiasts alike to create and share limited, theme-oriented geospatial information. A wide range of VGI activities have taken place in recent years. A few examples of successful VGI are:

1. OpenStreetMap (OSM)

OpenStreetMap (OSM) aims to map data that is free to use, editable and licensed under a new copyright scheme, the creative commons, to enable free access to current digital geographic information across the world (Hakley, 2010). By relying on VGI contributions, OSM is able to develop a map product that competes with commercial maps. In the study conducted by Hackley (2010), the comparisons between OSM and OS road maps showed that VGI can reach very good spatial data quality.

2. Google Map Maker

Google launched mapping applications with collaborative features, most importantly Google Maps with the Google Map Maker feature. Tools such as Google Map Maker have documented an enormous mass of overlay information on the base maps today contributed by individuals.

3. Wikimapia

Wikimapia (www.wikimapia.org) is an open content collaborative map where anyone can create place tags and share knowledge. It is a project to ‘‘describe the whole world’’ by identifying and providing detailed descriptions of point or area features. Wikimapia is, in effect, a crowdsourced gazetteer (Goodchild, 2008), a catalog of place names, geographic locations and feature descriptions. Wikimapia adapts some of the procedures that have been successful in Wikipedia and those applied to the creation of gazetters. Anyone with an Internet connection can select an area and describe it, edit features, and volunteer reviewers monitor the result by checking for accuracy and significance (Goodchild, 2007).

4. Humanitarian OpenStreetMap Team (HOT)

This application was developed to support the disaster management community. The Humanitarian OpenStreetMap Team (HOT) is a not-for profit organization launched in 2009 with the objective of open data sharing for humanitarian response and economic development. OpenStreetMap is a project to create a free and open map of the entire world, built entirely by volunteers surveying with GPS, digitizing aerial imagery, and collecting and liberating existing public sources of geographic data.

5. Crisis Mappers

The International Network of Crisis Mappers is an organization bringing together diverse individuals from the humanitarian, human rights, policy, technology, academic communities and skilled volunteers to catalyze communication and collaboration among a wide range of communities with the purpose of advancing the study and application of crisis mapping worldwide. Authoritative data is increasingly out of date in many parts of the world and was acquired using older technologies that were less accurate than those available to the general public today (Goodchild and Li, 2012). VGI has the potential to be a significant source of information for a variety of applications.

H. Types of VGI

Based on the motivation of contributors, VGI is classified into three types: market driven, social networking and civil / government.

1. Market-driven VGI

Firms like TeleAtlas, Navteq and TomTom use web-based customer input to locate and qualify mapping errors and/or feature updates required in their road network databases (Coleman et al., 2009).

TomTom is a company that designs and develops innovative navigation and mapping devices, as well as state-of-the-art fleet management solutions and location-based products. As a commercial company, TomTom uses the location data collected by users, with the permission of the user. The community is producing location and traffic information while using portable navigation devices that are then used by TomTom to improve the service for the community of users by updating maps, providing real-time traffic information etc. This form of community data collection or VGI is beneficial to the whole community of product users.

2. Social networking VGI

GeoTweeting is another feature that facilitates VGI, launched by Twitter. GeoTweet adds map links to tweets with optional photos and notes. It is also an example of VGI that can be used for disaster and emergency situations. It is used for monitoring and reporting activities, incidents or events in real time, reported by users at their locations.

3. Civic /government type of VGI

Under this category, falls Ushahidi, a global non-profit technology company that specializes in developing free and open-source software for information collection, visualization and interactive mapping. Ushahidi originates from Kenya, initially developing the Ushadidi platform to map incidents of violence in Kenya and peace efforts throughout the country after the post-election violence at the beginning of 2008, based on reports submitted via the web and mobile phones. The Ushahidi platform is built as a tool to easily crowdsource information using multiple channels, including SMS, email, Twitter and the web. The crowdmap application is hosted in the Ushahidi platform to crowdsource information, and is applied to different disaster situations to measure the impacts of disaster.

I. Rationale for the guidelines on VGI

In the past few years, a lot of effort has been put in developing community-based methods to capture and analyse a large amount of volunteered geographic information. This new source of geo-referenced data could be very important throughout Africa where volunteered geographic information or crowdsourcing activities involving citizens are best positioned to support better understanding of local issues and therefore the development of decision-support strategies and mechanisms. National Mapping Authorities should therefore consider this potential source of data to supplement and improve the coverage of their national mapping. Governments need to take proactive measures to develop strategies maximizing on the opportunity in the current technological development. This calls for the need to pay close attention to developing strategic guidance on how to strengthen communities' participation in data collection.

As a first step, ECA conducted a workshop on community mapping in March 2013 to introduce the concepts of community mapping, crowdsourcing and Volunteered Geographic Information (VGI), to discuss the methodology for mainstreaming VGI into national mapping programmes, the challenges and issues as well as the way forward to develop guidelines.

As a follow-up activity, ECA planned the development of guidelines for the best practices and principles for adopting community mapping in the mapping practices in Africa. This background document is intended for discussion and serves as a stepping stone to the development of the guidelines. An expert group meeting is therefore being organized to gather experts in the field to discuss the issues, develop a roadmap for the adoption of the technology and to agree on the guiding principles.

1. Global objective

The overall objective of the guidelines is to sensitize national mapping agencies on VGI and seek ways and methods of incorporating VGI mapping into their national mapping programmes and other mapping activities.

2. Specific objective

The specific objective is to raise the issue of VGI and review best practices as well as the current status on VGI mapping in the African continent. This will usher in the development of a roadmap for the adoption of the technology with agreed guiding principles.

3. Expected outcomes

VGI has the potential of being an important source of information for a variety of web GIS applications, including real-time disaster monitoring and early warning. According to Goodchild and Li (2012), VGI has enormous advantages: it is free, can be timely and can provide types of data not previously utilized in mapping practices. There would be great benefit if its quality could be improved and assured. This new source of geospatial data will be important for Africa where community mapping activities enhance participation and decision-making based on local knowledge. This will especially help national mapping authorities to build and update their national geospatial data sets, and improve the availability and currency of countries' fundamental and thematic data sets.

II. Chapter Two

A. VGI trends in Africa

The emergence of Web 2.0 created the possibilities of user-generated content. In recent years, there have been many examples showing that ordinary citizens, with no geography or GIS training, are beginning to use geospatial information. New mobile technologies also brought what was once in the domain of GIS experts to mainstream society. Location-based applications and services on mobile devices are changing our world into one in which any citizen with a GPS-enabled phone can become a geo-sensor to collect data and attributes on a particular location and, more importantly, broadcast this information to the world voluntarily using the Internet and social media. This crowdsourcing innovation is considered to be the future trend in geospatial industry development. Recently, African countries have also been following the global trend in harnessing the information contributed by citizens, specifically VGI. There are a number of cases where African countries have implemented VGI projects and local governments showed interest in the adoption of crowdsourced information.

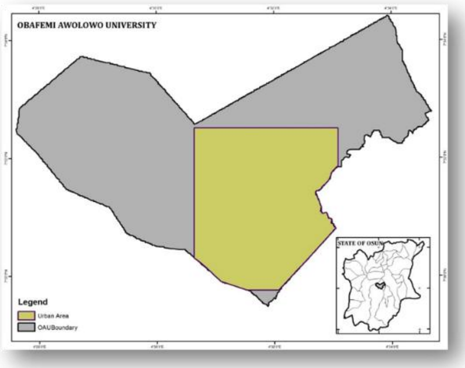
B. Best practices: Overview of the African VGI landscape

1. The Role of Unmanned Aerial Vehicles (UAV) in GIS of developing countries

One of the best examples of this is from the Obafemi Awolowo University, Nigeria. The main applications of UAVs in VGI include observation, maintenance, surveillance, monitoring, remote sensing and security tasks. With respect to observation, micro UAVs have been applied in many studies based on their capabilities in the production of spatial data sets such as aerial photographs, orthophotographs and digital surface models. The Obafemi Awolowo University GIS Initiative was initiated without considering the use of UAVs but, as the project advanced, the use of UAVs was integrated into the project.

The Obafemi Awolowo University was established in 1962 and is located in Osun State, Nigeria, and lies within Latitudes 7° 29' N and 7° 34' N and Longitudes 4° 27' E and 4° 34' E.

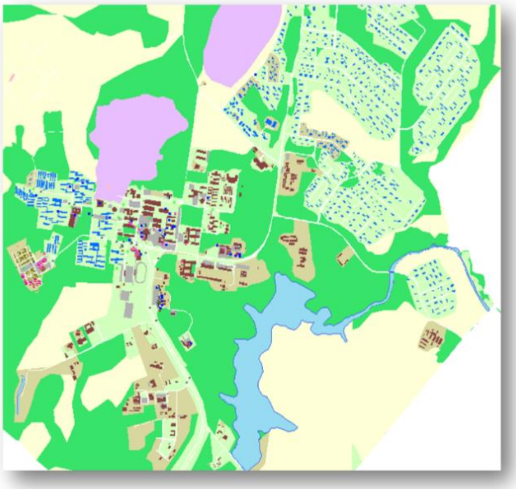
The university has a student population of over 30,000 and staff strength of about 5,000 and a total surface area boundary of 12,450 hectares with an accompanying urban area of 1,959 hectares (4,842 acre). Since 1962, the campus has expanded without a corresponding update of the campus map for planning and other purposes. It was imperative to update the campus map, and this was conducted voluntarily by staff and students using UAVs.

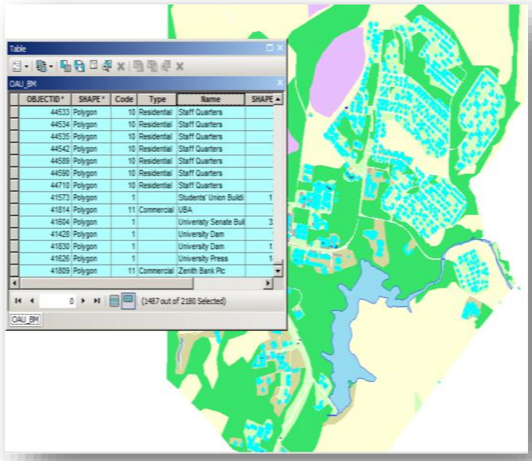


The ArcGIS 10.3 Authorization License was used and users were registered on www.spaeloau.org and focal persons from various departments were authorized to use the ArcGIS software aimed at enhancing the quality of the mapping exercise.

2. Production of Obafemi Awolowo University campus map

GoogleEarth images were captured in 2011, and these images were gridded in a preliminary planning method for mapping.





The gridded images were digitalized and merged for quarries to be generated. For instance, the selection of the total number of buildings within the built-up area of the campus is about 1,400 as at 2011.

3. Micro UAV (Phantom II vision)

The Obafemi Awolowo University GIS Initiative and the use of Micro UAVs utilized a low-cost Micro UAV (Phantom II vision) on the Obafemi Awolowo University campus to obtain some spatial products for the project. The UAV Phantom II specifications were: Weight: 1160g, size: 29 x 29 x 18 cm, max communication distance: 300m, ground station support: remote control, total flight time: 25 minutes, waypoints automated flight (max 200m flying height), camera type optical (RGB), resolution: 14MP and format: raw and jpeg

Remote control

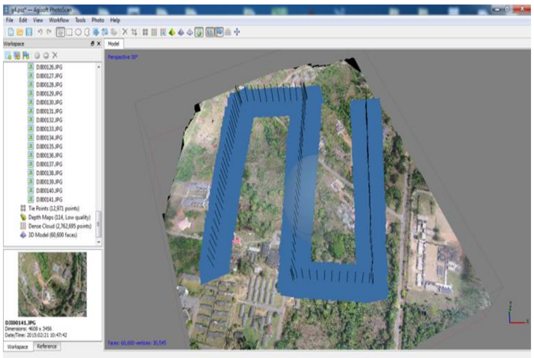
UAV (Phantom II vision)

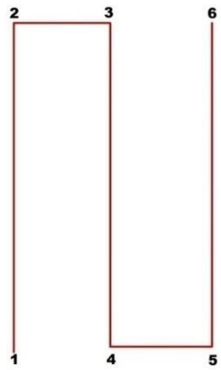
Aerial photographs of some buildings on the Obafemi Awolowo University campus as mapped by UAV (Phantom II vision)

Faculty of Agriculture Building | Amphitheatre and Oduduwa Hall

4. Digital orthophotos

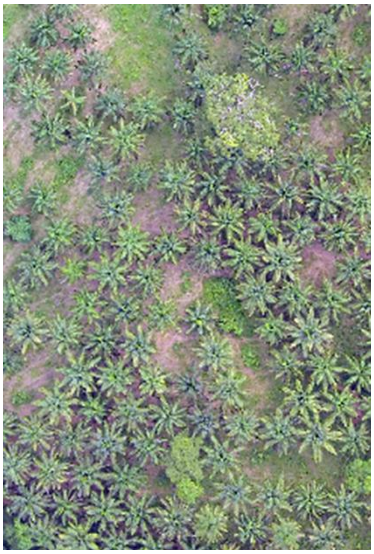
An orthophoto is an aerial photograph, which has been geometrically corrected and thus has uniform scale. A series of overlapping images was obtained over a small area. The images were processed and merged together to produce an orthophoto and digital surface models.





UAV (Phantom II vision) flight path waypoints sketch

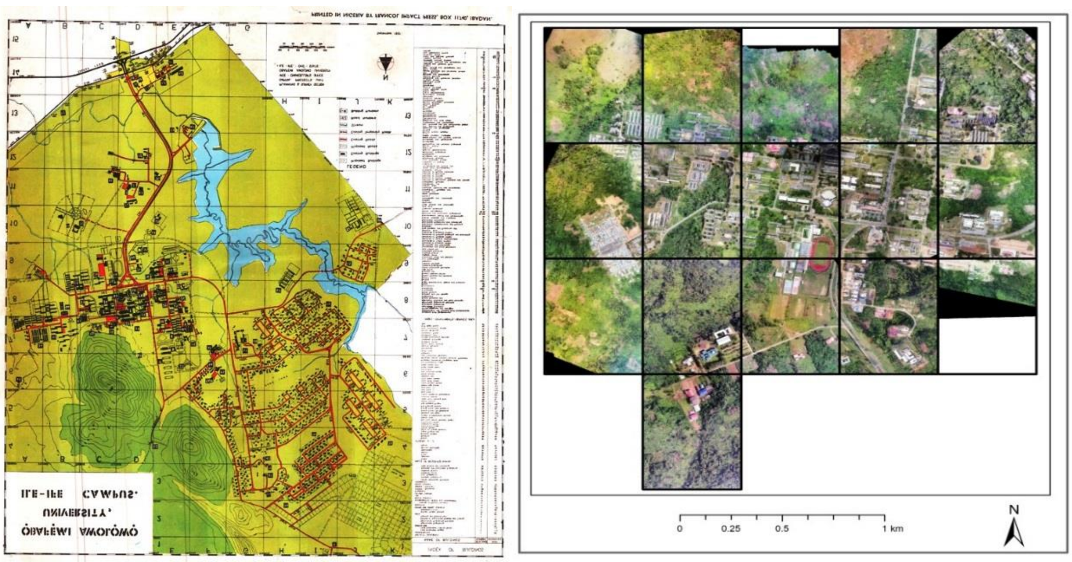
Digital orthophotos



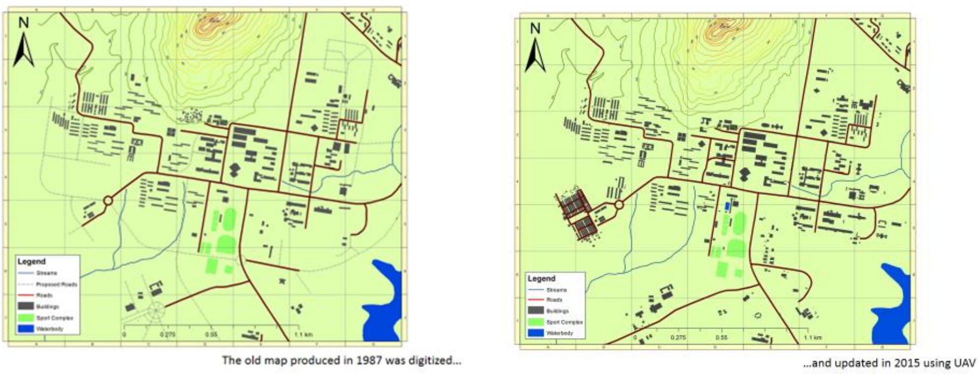
An orthophoto of part of the central campus area showing the yellow house, Amphitheatre, the library, the Central Market, the Oil Palm Plantation and the Teaching and Research Farm

The digital surface model of part of the central campus area

5. Results



The old and new orthophotos of the Obafemi Awolowo University campus. The orthophotos were put together to obtain an image that covers a bigger study area.



The updated map is being used for planning-based decision-making in the campus (Salami, 2015).

C. Supporting community interventions, planning and development through VGI

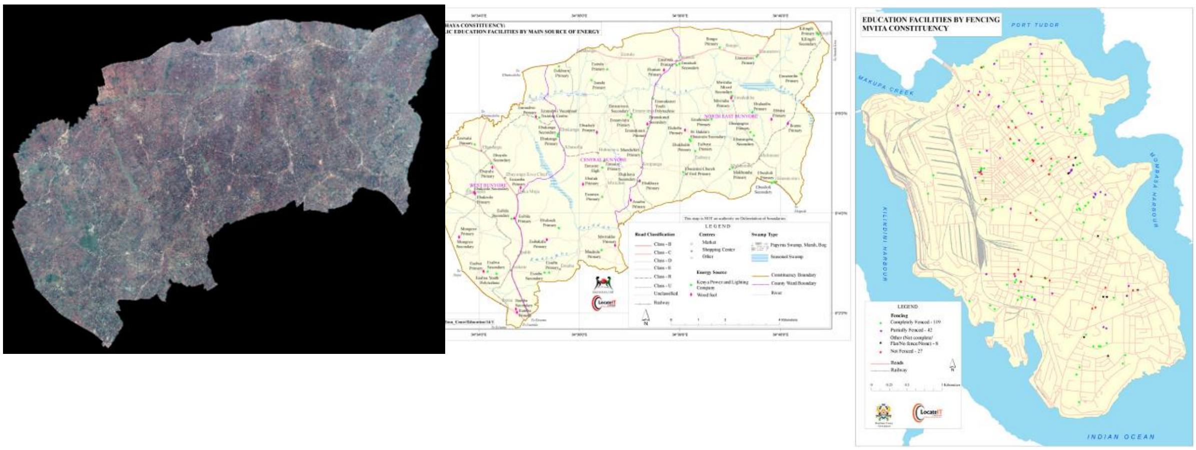
There are several community interventions through VGI in Kenya, some of which are:

1. Community GIS Platform

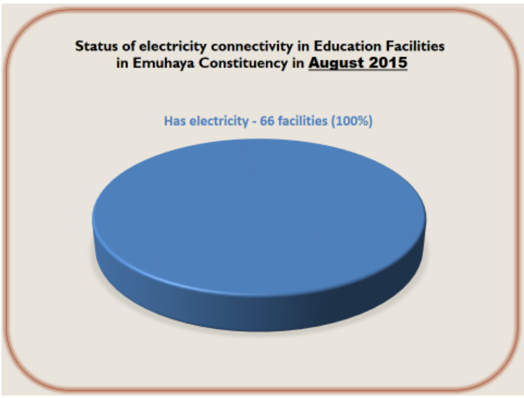
The key strengths of the Community GIS Platform is that it has created employment opportunities for youths to map socioeconomic issues via smartphone geo-applications. It has demonstrated the fact that it is a quick way to collect large amounts of data in a relatively cost-effective manner and the data is immediately visualized via GIS / geo-portals.

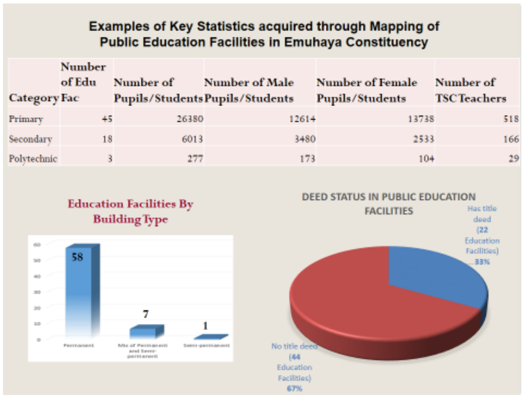
Mombasa County: Training of 90 youths in the use of geo-apps for field data collection (September 2014)

2. Outcomes of the community mapping



Socioeconomic mapping of Mombasa County by Local youths using smartphones

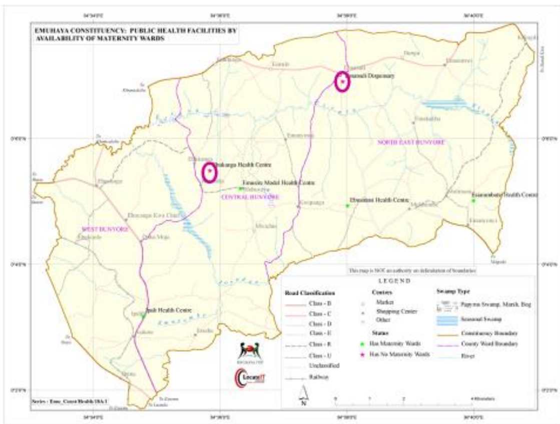




Examples of Key Statistics acquired through Mapping of Public Education Facilities in Emuhaya Constituency

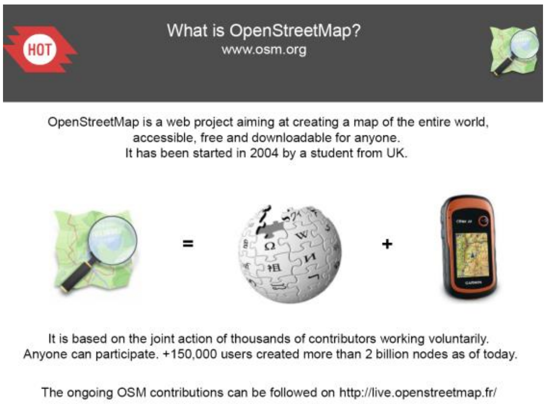
Category	Number of Edu Fac	Number of Pupils/Students	Number of Male Pupils/Students	Number of Female Pupils/Students	Number of TSC Teachers
Primary	45	26380	12614	13738	518
Secondary	18	6013	3480	2533	166
Polytechnic	3	277	173	104	29

The data generated has led to the electrification of educational facilities in Emuhaya Constituency in Kenya.



Community GIS Platform has helped decision makers in locating new primary schools and reducing the time children use walking to school (Erick Khamala, Accadius Sabwa, 2015)

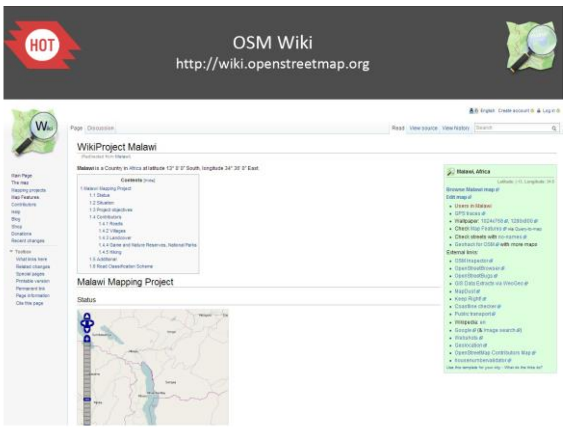
D. HOT OpenStreetMap humanitarian maps



1. OpenStreetMap

OpenStreetMap is a web project aiming at creating a map of the entire world; accessible, free and downloadable by anyone. It was started in 2004 by a student from the United Kingdom. It is based on the joint action of thousands of contributors working voluntarily. Anyone can participate. More than 150,000 users have created more than 2 billion nodes to date. The ongoing OSM contributions can be followed on http://live.openstreetmap.fr/.

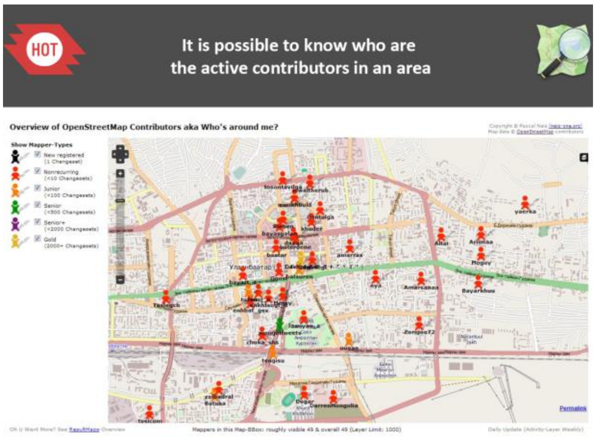
OSM focuses not only on all the visible, physical objects like roads, buildings, land uses, facilities (health, education, etc.) shops, industries, water and sanitation, natural spaces but also on invisible ones like administrative boundaries.



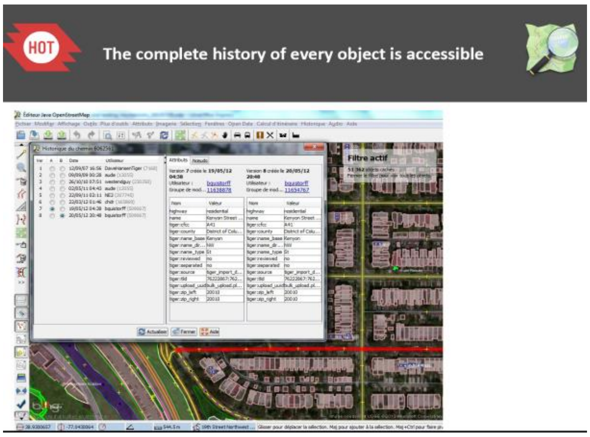
2. OSM governance

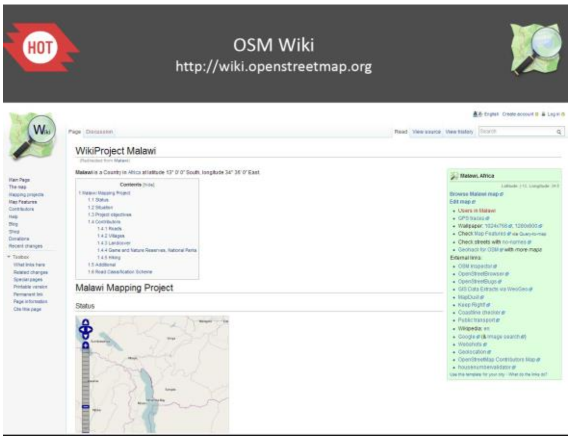
The ecosystem of the OSM community consists of citizens, associations, local governments (Badan Nasional Penanggulangan Bencana— the National Disaster Management Agency in Indonesia), NGOs, International organizations (the United Nations, World Bank, United States Agency for International Development, Australian Agency for International Development and academia). Private actors include Microsoft, Foursquare, Cloudmade, Geofabrik, Camptocamp and MapBox.

The growth of the OSM project is fostered by the OpenStreetMap Foundation and local chapters as well as the Humanitarian OpenStreetMap Team for Humanitarian/Development contexts.

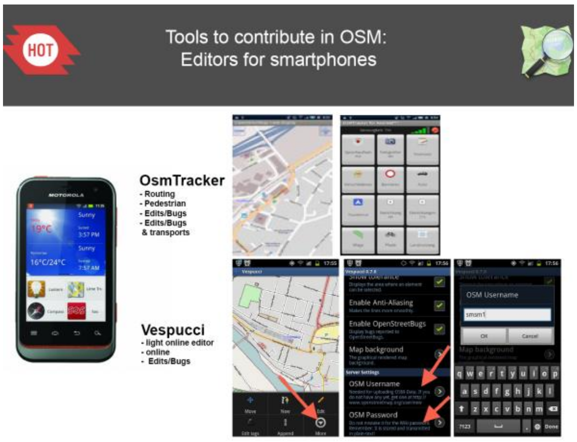


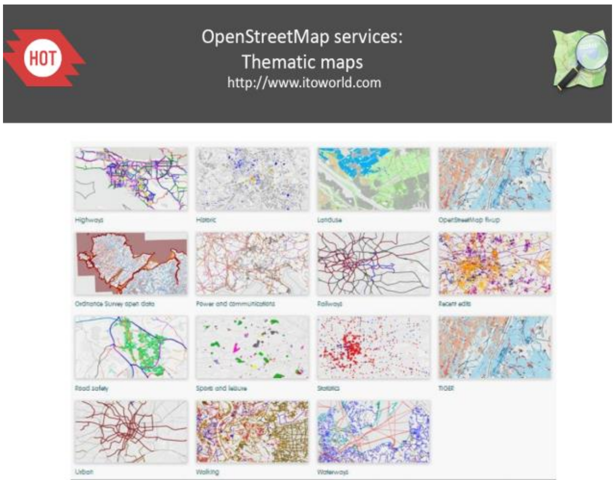
Idea (same as Wikipedia): A large number of individuals contributing in one pool will tend to create high quality data. There are free mapping and quality validation tools. Different kinds of practices and tools strengthen this: Quality control tools over an area and easy access to each step of the history of every object. There is also easy access to all the contributions of every mapper and the possibility to reverse any bad contribution.

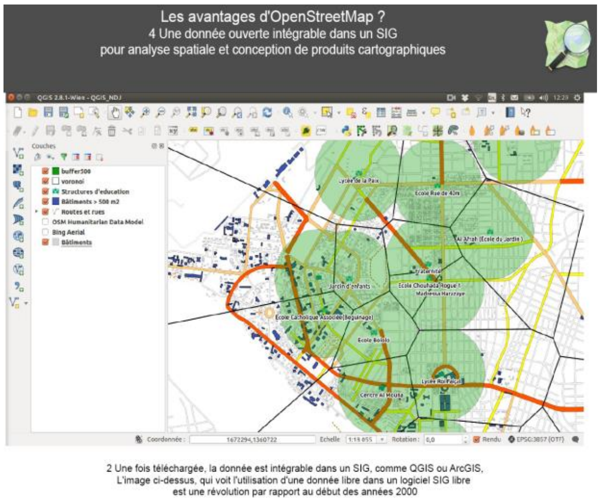


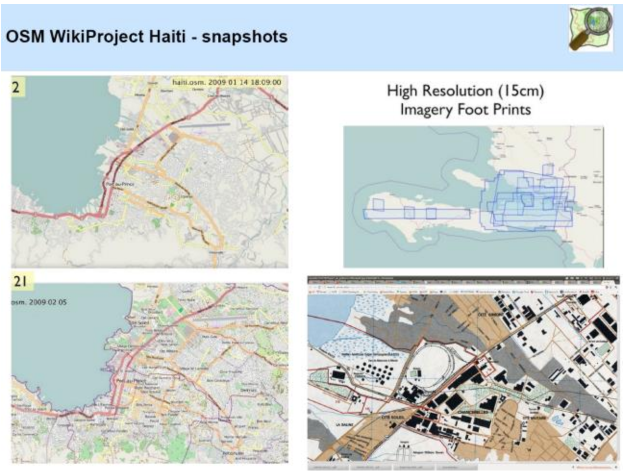


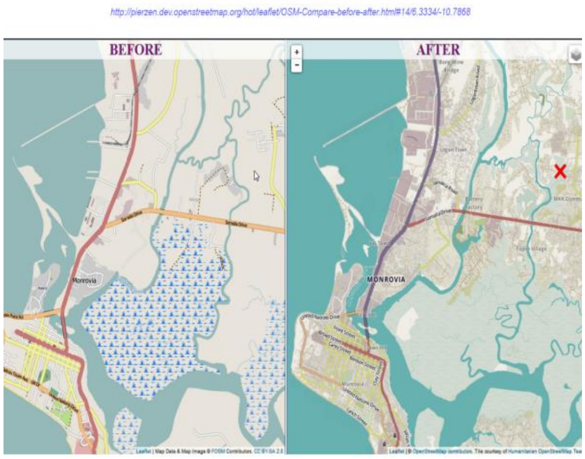
The Humanitarian OpenStreetMap Team acts as a bridge between the OpenStreetMap community and the humanitarian actors. It assures a quick response, interacting and establishing priorities with the humanitarian actors: United Nations agencies, international organizations, national governments, imagery providers, imagery acquisition and processing, crowdsourcing, remote mapping, open-source tools development, assures data exports in various formats and responds to humanitarian-specific needs.











3. Other examples of implemented VGI projects

A few of the examples of implementation of VGI projects, from the study conducted by Hakley and others (2014) and compiled as a report to the World Bank's Global Facility for Disaster Reduction and Recovery (GFDRR) are presented below:

(a) Kenya: Map Kibera project was launched in 2009 with the aim to map the unmapped Kibera by actively involving the local people. The process involves collecting GPS tracks and tracing them in the OSM platform. The project also offered an opportunity for mappers to enhance points of interest such as water points, schools, public toilets, police stations and clinics. The project was accepted by the local government.

(b) South Sudan: The aim of the project was to engage volunteer Sudanese in the Diaspora to map the poorly mapped South Sudan so that the infrastructure and the economy of the country could be developed. The project was launched in 2011 and implemented by Google with the support of the World Bank, United Nations Institute for Training and Research (UNITAR) Operational Satellite Applications Programme (UNOSAT) and Regional Centre for Mapping of Resources for Development. The process involves satellite imagery of the region uploaded to Google Earth and editing and updating maps on Google Maps using Google Map Maker. Citizens update maps using available web tools and their local knowledge and, after approval, the map is made available in Google to all users worldwide. The project was also accepted by the local government and international organizations. The mapping was used by the Satellite Sentinel Project, the Enough Project, Not On Our Watch, UNITAR, UNOSAT, Digital Globe, the Harvard Humanitarian Initiative and Trellon.

(c) South Africa: The iCitizen project in South Africa was launched with the aim to improve the lives of citizens by collecting reports on fundamental problems with infrastructure and services and passing them to the relevant authorities for intervention. The process involves reporting of issues by the public through forwarding geo-tagged photographs, sending in locations via SMS, or reporting issues via email.

(d) Uganda: The Community Knowledge Workers (CKW) initiative in Uganda aims to train local people in the use of technology for data collection and sharing farming knowledge to improve their farming efficiency and, as a result, improve their livelihoods. Participants of CKW use their mobile phones to collect information on livestock and crop farming. The data collection takes place offline using the GPS sensor of a mobile device and properly-designed forms. Once the phones are in areas of wireless or mobile network, the data is transferred to the central server and shared with other farmers and users. The information shared in turn helps farmers and policymakers to address the needs of farmers and provide market price updates, receive weather forecasts and access potential disease outbreak updates, etc.

(e) Somalia: UNHCR, DigitalGlobe, Tomnod, the Standby Task Force and Ushahidi collaborated in a humanitarian project to geo-locate and map all shelters in Somalia’s Afgooye corridor with the aid of satellite imagery provided by the Standby Volunteer Task Force. The goal of the project was to test the feasibility of crowdsourcing rapid shelter enumerations of internally displaced persons to help in population estimates.

4. Emerging issues in VGI-specific science/ technology

Like any other new research field, VGI faces issues or common problems to be addressed or that need further research. These issues include data and knowledge discovery, data uncertainty or accuracy, human privacy or liability, the motivation for VGI, etc. (Jia, 2010). Data discovery will indeed be a major issue. As the big data coming from the VGI community exponentially increases, accessing spatial data and identifying its usability might be a problem. Data quality and uncertainty are also concerns in VGI.

In most cases, the spatial data collected by volunteers does not go through formal quality control procedures. The quality of VGI also depends on the source data used to produce it as well as the knowledge of the contributor. Data contributed by amateurs could be less accurate than data contributed by professionals. The risk of national authorities being unable to adapt to the paradigm shift is another issue in implementing VGI technology. As Coleman and others (2009) put it, the potential exists for government mapping agencies to harness the power of new media and voluntarism in order to improve their own change detection and geospatial data updating processes. It has the power to complement existing practices and enable new production systems.

However, these certainly bring about tensions and modifications to cultures, policies and processes necessary for established public sector organizations to accommodate volunteered information to their databases. If national mapping organizations wish to tap into the distributed knowledge, time and energy of volunteer producers to contribute authoritative geospatial data, they must be prepared to entertain some important procedural and cultural changes.

If a mapping organization wishes to capitalize on a distributed network of volunteer geospatial data producers (a concept used to define the volunteers who collect data/information voluntarily as data producers and also use volunteered information as consumers or users), then it must start refocusing attention across what happens both inside that organization and also in the new social network of geo-information production. New rules and standards will be required to take into account the values of these volunteers—equity, security, community building, privacy—in evaluating the performance of this new production system (Coleman et al., 2009). The report of the World Bank by Hakley and others (2014) also highlighted that VGI should not be seen as an activity that will replace the work of professionals but as one that enhances it.

However, in most cases, VGI is perceived as a challenge to existing procedures and professional standing, which leads to negative response. There is also need to integrate VGI processes (including issues of engagement and feedback to contributors) into established systems, practices and procedures. The study also indicated that adopting crowdsourcing will require additional resources to manage the crowdsourcing process, the data collected and engaging with the communities involved. Therefore, governments should consider long-term plans and assess the sustainability of their adoption of crowdsourcing.

III. Chapter Three

A. VGI applications

1. Updating fundamental data sets

The utilization of VGI for spatial information collection and updating is widely used by businesses such as TeleAtlas, NAVTEQ, Google and OpenStreetMap. Government organizations are also recently employing volunteered input into their mapping programmes. Government organizations have now also realized the power of VGI and crowdsourcing and are interested in utilizing these technologies for Spatial Data Infrastructure (SDI) development (Paudyal and others, 2012). Government departments must first of all determine the quality of VGI data before combining the generated data with NMA authoritative data sets as issues related to the scale and accuracy are important to be determined before inclusion into NMA's spatial databases. It is therefore the responsibility of NMAs to determine the sustainability of the VGI incorporation processes into NMAs spatial databases.

National mapping agencies can use, for example, Google Maps and OpenStreetMap to update their fundamental data sets. Road Map as one of the framework data sets can be updated using these maps. Authoritative mapping organizations should extend these services to permit incremental updates to existing databases (Coleman, 2010). Coleman also gave examples where state governments in Victoria, Australia and North-Rhine Westphalia, Germany employ volunteered input to their mapping programmes.

2. Statistics

Data collection is facilitated by using new technologies such as the use of mobile devices and digital map applications such as Google Maps and Web 2.0 technologies. Volunteers can collect data/statistics in different themes and sectors including their location.

B. Thematic

1. Natural Resource Management

A study was conducted by Paudyal and others (2012) to understand the use of VGI in the area of catchment management in Australia. This study identified the major community-driven or volunteer initiatives that spread over all the themes such as land, water, biodiversity, coast and marine for catchment management. The major ones from these volunteer activities include: Landcare, Waterwatch, Coastcare, Land for Wildlife, Birdwatch and Vegewatch. The authors (Paudyal and others, 2012) concluded that the level of applicability of open-source products and VGI to various catchment management issues is very high.

2. Biodiversity

VGI is also used in biodiversity studies to collect data on biodiversity, to display information and to geo-reference that information. VGI in biodiversity studies involves an array of data gathering, from the compilation of data on species occurrences to information on species abundances, all collected by volunteers.

Data gathered by volunteers has been prominent for collecting plant species and for bird count, as well as breeding bird surveys. VGI plays a critical role in monitoring biodiversity in the face of increasing species extinction, and can provide substantial support for biodiversity research. There are several important VGI initiatives that are ongoing today that provide critical information that may be used by researchers. These include: eBird, Audubon Christmas Bird Count, Breeding Bird Survey, e-Flora and e-Fauna.

3. Tracking

VGI can be used for tracking and fleet management in emergency situations. Since most people now use GPS-enabled smart phones, these can be utilized in an emergency. A VGI-based fleet tracking solution adds tremendous capability in an emergency situation. Supervisors and other emergency workers can not only know where official responders are but they can also know the locations of volunteers. This makes the task of coordinating their efforts much easier and keeps them informed on the progress of both responders and volunteers.

Hamilton and Janowicz presented cases of three crises situations in Florida; flooding, a tornado and a hurricane. By using volunteer geographic services, the progress of the volunteers is constantly monitored since their GPS-enabled smart phones periodically update their location. This allows supervisory staff to more efficiently route volunteers and to track their progress towards their destinations. Thus the residents in the flooded area know that assistance is not only on the way but they know approximately when it is due to arrive and what is coming (Janowicz, 2014).

4. Disaster management/emergency situation

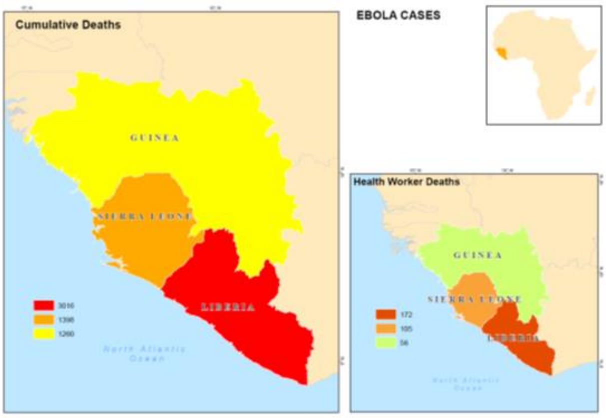
VGI is becoming especially useful during emergencies where responders are not in a position to access critical data in real time. Emergency responders have limited staff and ability to acquire and synthesize the geographic information that is vital to effective response. In many cases, people living far from the affected area have been better informed through the media than those managing and carrying out the relief effort (Glennon, 2010). Affected areas often lose power and Internet connectivity, impeding access to relevant information and computing capabilities. Today, volunteers have mobile devices equipped with digital cameras, GPS, digital maps and numerous other resources and they are in a position to contribute during such emergency situations. Moreover, citizens are able to access and interpret data streams from satellites with comparatively fine temporal and spatial resolution. They can compile this information and synthesize it in the form of maps using services such as Google Maps, and provide easily accessible and understood disaster situation reports (Goodchild and Glennon, 2010).

Goodchild also stressed, in his keynote speech in a VGI workshop (ESRI, http://www.esri.com/, 2011), the importance of timeliness in VGI to create an accurate picture of what's occurring and when in a particular situation. He also stated that VGI can readily be referred to as the most current data source though it has been criticized for having poorer positional accuracy and overall veracity. He countered this, citing Linus's Law, which states that the more people are involved and watch over a project, the more likely errors can be spotted and fixed quickly. He further stressed that the contributions of citizens will tend to be more accurate for places they live in and know best, quoting Tobler's Law, which states that, “Everything is related to everything else, but near things are more related than distant things.” (ESRI, http://support.esri.com/, 2016)

Goodchild, in his keynote speech, also said that, “The most compelling case for VGI is during emergencies”. In the event that experts are scarce on the ground, it’s important to turn to citizens who can contribute data through social media or other means, in the context of relying on the currency and coverage (ESRI Arcwatch, 2011).

A good example of VGI in emergency situations is the response to the Haiti earth quake in 2010. OpenStreetMap project volunteers working outside Haiti created a digital street map of Port-au-Prince and other places in Haiti very rapidly using fine-resolution imagery to trace vector maps of streets and other features. The Ushahidi Project was also supporting the response by posting appeals for help, providing translation from Creole (local language) into English by another group of online volunteers that are not part of the Ushahidi Project. Together, these VGI projects were instrumental in guiding first responders to disaster victims. The International Network of Crisis Mappers (also an Ushahidi collaborator) has established the Standby Volunteer Task Force: An Online Community for Live Crisis Mapping. Crisis Mappers also helped the Haiti earthquake disaster response in 2010 by organizing the digital response to the disaster.

C. VGI and the West African Ebola epidemic



The Ebola outbreak that struck Guinea in March 2014 later spread to Liberia, Sierra Leone and Nigeria causing 1,711 contaminations and 932 deaths by the start of August. Relief organizations took action to contain the spread of this highly infectious and deadly viral disease. It was critical for the mapping community to work to identify affected areas rapidly throughout the territories of the infected countries. Comprehensive and precise maps of the regions were vital. Organizations such as Médecins Sans Frontières, CartONG and Red Cross are working closely with the Humanitarian OpenStreetMap Team to coordinate the mapping community to deliver maps to field workers through VGI.

Below are the various steps of the workflow for this Ebola initiative:

- Pinpointing areas to map, services to provide, priority setting and coordination with CartONG / Médecins Sans Frontières, Red Cross, United Nations Office for the Coordination of Humanitarian Affairs and World Health Organization;

- Interfacing with field GIS officers through CartONG;

- Imagery acquisition, processing, host imagery on servers (OSM-Fr, HIU and Mapbox servers);

- Digitizing from Imagery the roads, villages, buildings;

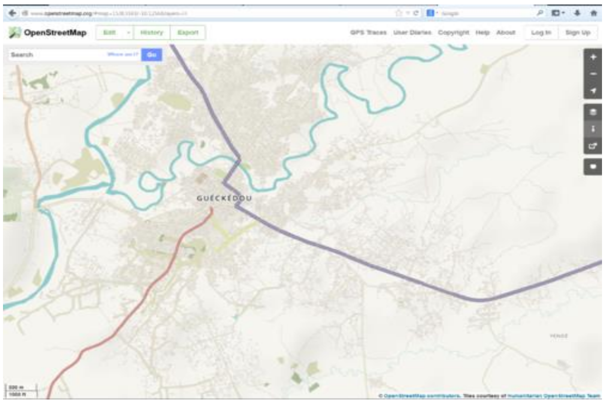
- Data imports for administrative limits, locality names (Open data needed);

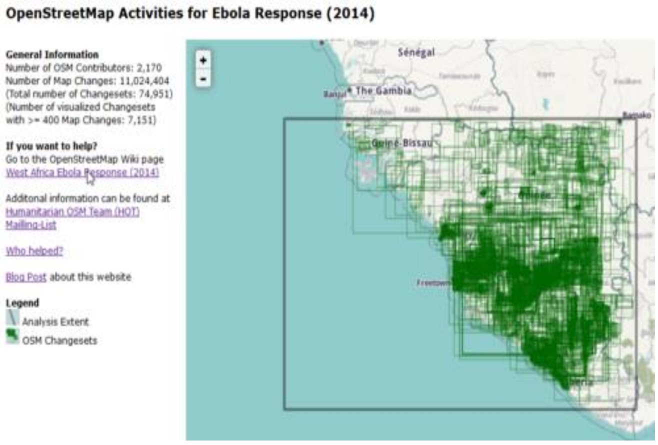
- Infrastructure data collection: An ecosystem to develop with humanitarians plus data preparedness programmes;

- Support the crowdsourcing mapping effort – Coordination via the task manager, learning material, mapathon, communications;

- Daily update for GIS analysis, mobile device maps and road navigation. Also available: Online map and road navigation, paper maps, field papers etc.

The input of the OpenStreetMap community to the Ebola outbreak was unprecedented with more than 8 million objects. More than 90,000 km of roads, 650,000 buildings and 20,000 place names have been added in Guinea, Liberia and Sierra Leone.



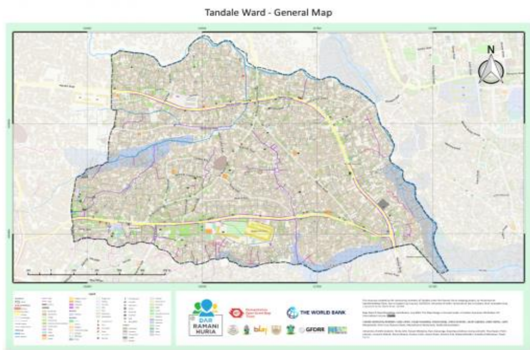


Source: http://wiki.openstreetmap.org/wiki/2014_West_Africa_Ebola_Response.

D. Tanzania

Dar es Salaam is one of the fastest growing metropolises in Africa, with a yearly population growth of over 5 per cent. In 2002, there were roughly 2.5 million inhabitants, growing to 4.4 million in 2012. The population is likely to surpass 10 million by 2040, making Dar es Salaam a megacity. Urbanization is generally unplanned, and more than half of the city’s inhabitants live in informal settlements. The deprived citizens who settle in these areas not only have less access to basic services, but are also the most exposed to natural hazards.

In 2015, HOT started an initiative to map infrastructure data in various parts of Dar es Salaam. This exposure data will be combined with flood hazard data to conduct risk analysis of possible future disasters. Throughout the year, the local OSM community was strengthened through mapping activities and trainings, building capacity in community mapping techniques and risk analysis with the aim of improving awareness and resiliency to natural threats.



Source: http://hotosm.org/updates/20150923_community_mapping_has_long_lasting_impact_in_tandale_dar_es_salaam_tanzania.

E. Malawi flood preparedness

HOT carried out a project in Malawi whose main aim was to do a community mapping exercise for the Lower Shire, the large valley in the South whose two districts, Chikwawa and Nsanje, are the most flood-prone areas of the country. This project was funded by GFDRR, for which Malawi is one of the 9 African priority countries.

The project complemented other initiatives implemented previously by GFDRR with the Department of Disaster Management Affairs), the Surveys Department (the one in-charge-of maps and geodata) and other relevant government departments. These initiatives include an Integrated Flood Risk Management Plan for the Shire Basin, an open data, Geonode-based platform called Malawi Spatial Data Portal and a specific needs assessment report for Nsanje (the Nsanje 2012 Floods Post Disaster Needs Assessment).

The aims of this project were to:

1. Hold a series of meetings and training sessions on open data and community mapping, engaging government departments, university students (especially from the Polytechnic School in Blantyre), NGOs and civil society.

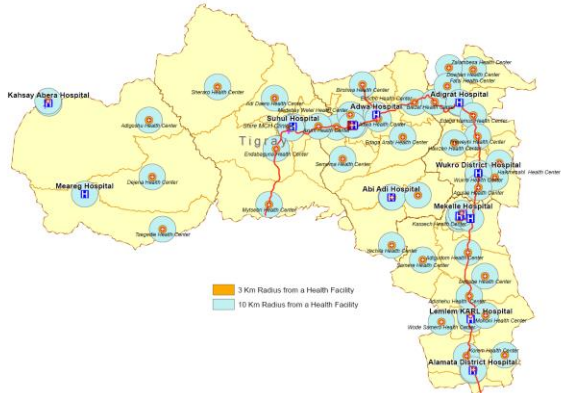
2. Apply the training by collecting geospatial data in the field in the two most flood-prone districts of Malawi (Chikwawa and Nsanje), edit and upload it in partnership with the OSM worldwide community that has already shown its huge impact when mapping on imagery or editing field collected data.

3. Explain how to host the data on the Malawi Open Spatial Data Portal and how to use it effectively, especially by holding a training on the INASAFE tool to perform contingency planning with the OSM data, as already made elsewhere, especially in Indonesia.

4. Identify and support community mobilizers to ensure sustainability of the outcomes, and make the community autonomous; able to update and enhance the OSM data, use it when crisis arises, and link with the local disaster management authorities and the OSM worldwide community.

F. Central African Republic activation

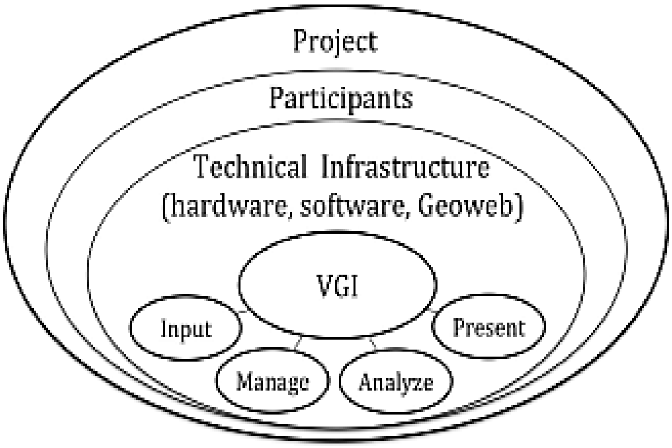
Since December 2012 when the Séléka Rebellion started, Central African Republic has been suffering dark times and has become a level crisis for the United Nations. Unfortunately, this crisis will likely last for years. HOT was involved in a field project before the crisis started and remote mapping has been continued when the rebellion started in the country. In April 2013, when Bangui, the capital City, fell to the rebels, a HOT activation was launched. This activation aims at mapping the country on a systematic way, in order to provide the best possible baseline data humanitarian stakeholders need and to facilitate development projects as soon as the local situation improves.



IV. Chapter Four

A. VGI data collection systems

VGI as crowdsourced data is vital for creating, collating, analysing and disseminating geospatial information. This data is usually harvested by individuals and groups using a volunteer participatory approach. There are devoted sites that permit users to create their own content by providing locational and other information. VGI as a data gathering source has been evolving speedily and users have been playing substantial roles in its development as well as in harnessing information for decision-making (Granell & Frank , 2014).



Source: (Victoria Fast, 2014).

1. User-generated content

VGI principally relies on organized user-generated content and, over the years, the media has led this process in areas including, but not limited to, blogs, wikis, chats, digital imagery and discussion forums. Users have migrated and are using free and open-source software in the process of generating VGI data. This harvested data has to have a logical workflow, such as storage and output or service architecture formats (Ostermann and Laura, 2010).

2. General requirements for users to generate content

In order to produce VGI data, a facilitator or enabler is required to manage the process and the audience provide feedback by entering the generated spatial data. This is a two-way approach and this method is being used in Web 2.0, drastically lessening passive audiences. This creates a conducive environment for publishing the data by individuals within and outside the geo-information profession. The following are some of the requirements for users to generate content:

B. Influence of the media

It has been observed that the genesis of VGI has been the mass media with the advent of the Internet and the use of mobile devices. User-generated news has encouraged the steady generation of VGI and other data types voluntarily. The media uses satellite images and other geo-enabled tools for collection and reporting of geo-localized data.

C. Driving forces influencing users

Implicitly, social and professional interests act as the driving forces leading to voluntary efforts for data publication. Explicitly, rewards in terms of finance are additional factors for the voluntary effort to publish VGI data.

It is worth noting that VGI data is not without hurdles as it raises various issues such as:

(a) Legal issues

The willingness to generate acceptable VGI data by users is bound to have legal implications; some countries restrict the voluntary publication of data. This stems from the fact that some content published is considered harmful, deceptive or inflammatory.

(b) Criticism

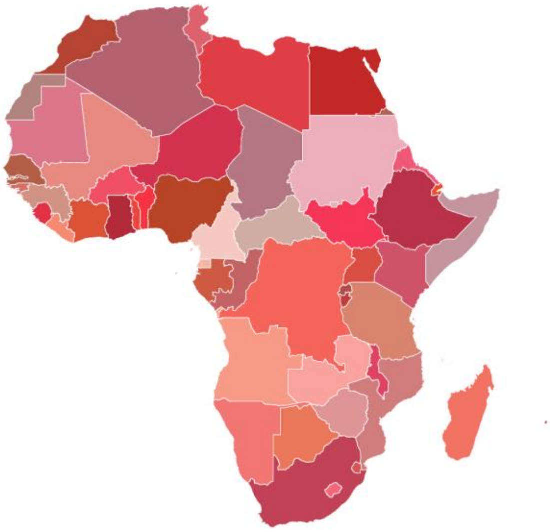
User-generated content in VGI has been criticized for being unfair as the quality of the generated data has not been guided by standards. Despite the criticism, user-generated content continues to grow as Internet and mobile devices will unceasingly generate user content.

D. Categories of data collection systems

(a) Point data collection: Geo-referenced points are collected for each unique feature. The points are located by their latitudes and longitudes, derived either from a GPS reading or directly from data loaded into a GIS software. After the locations are established, data is linked to the identified points.

(b) Line data collection: Lines are used to identify and demarcate linear features by continuously indicating their latitudes and longitudes while including attribute data to these identified features.

(c) Polygon data collection: Polygons are used to identify areas with the geographic coordinates creating an integral part of the process (Barbara, et al., 2012).



(d) Raster data collection: Rasters are used to identify areas with geographic coordinates as well as pixel information creating an integral part of the process.

E. Collecting VGI data

- **Collection by individuals**

The VGI data collection process by individuals should follow a general framework protocol that guides data generation for better accuracy and increased usability. The initial fears of using VGI as a replacement to authoritative data have subsided over time. Overall, the current situation for VGI is good and positive. However, there are still concerns about VGI accuracy, provenance and motivations. VGI cannot reach a high standard of quality and accuracy without rigorous protocols. Standards can only be guaranteed if citizens collect and submit accurate data and this depends on three factors: (a) clear data collection protocols, (b) simple and logical data forms, and (c) unceasing support for participants to understand the data collection process.

F. Collection process (collection by individuals and groups)

1. Joining the community

This is done by registering on a website and usually users have to possess an identifier and a password.

2. Data collection

Usually, the interface uploads background maps and digital images embedded in the platform and individuals follow instructions to collect points from screens of devices as well as digitize lines and polygons from the provided data. In certain cases, individuals use their devices to submit produced data to dedicated sites. The quality of the background information will determine the quality of the data to be collected. Accuracy, standards and precision are among several factors affecting the interpretability of VGI data.

3. Uploading the data

The collected data is uploaded on the website for cleaning, validation and publication. This process should follow a rigorous protocol and, equally, the linking of this data to dedicated official fundamental spatial data sets is imperative.

4. Data conversion

The collected data should be convertibly enabled to accept different formats, addressing the needs of users. The conversion mechanisms are usually embedded in the various platforms.

5. Editing the data

The generated data usually has background information made of satellite images, digital elevation models etc. This information helps to verify and edit the overlaid generated spatial data. It is imperative that these fundamental data sets stem from official sources.

6. Necessity for protocols

A protocol is a first step on a long road to improved stability and uniformity in the collection of VGI vector data. Protocols will improve the quality of data by increasing trust and understanding of the VGI process – possibly making VGI more appealing as a source of geographic data. Volunteers typically digitize information from aerial imagery with (large) positional errors or use uncorrected GNSS systems with positional accuracies in range 5 - 15m or more. The satellite images provided should be uniform with the resolution facilitating data harmonization (Paudyalab, K. McDougallab and A. Apanab, 2012).

G. Major barriers in generating VGI data

1. Data quality and validation

The positional accuracy of much of VGI may actually be insufficient for the needs of users.

2. Legal issues

There are issues of legal liability, copyright, etc.

3. Nature and motivation of the producers in the crowd

There should be assessment of the credibility of the sources and their intrinsic motivations. Sustainability and concerns about employment and efforts to sustain the VGI dataflow are essential. The nature of incentives should be determined to cast VGI not as a replacement but a complement to authoritative data. Measures for users on how to follow the protocols to submit their information are necessary for quality spatial data assurance.

H. Protocol considerations for collecting vector VGI data

This data can be collected in three ways:

1. Digitization from imagery

Data is collected through onscreen digitization from web mapping files or offline digitization from raster images.

2. Field survey

This uses tools such as GPS to survey real-world features like roads, urban areas, etc. It also uses geographic data available as open data or stored in open databases/formats.

I. Five major stages of a VGI protocol

1. Initialization

Project setup, device choice, application choice, data collection aims and objectives.

2. Data gathering

Planning the collection, having a strategy, keeping the necessary documents as well as reporting any technical or environmental issues encountered are essential in harvesting data.

3. Self-assessment/quality control

Carefully revising and checking any collected data to ensure efficient digitization and making statements on data quality assessment.

4. Data dissemination

Submitting or providing data in the VGI platform and ensuring that the submission process is completed.

5. Feedback to the community

The experiences, issues, improvements, use of protocols, etc. should be addressed by the community.

J. High-level priorities for VGI vector data protocol

(a) Develop a framework on how to collect accurate VGI vector data.

(b) Be real and practical in the framework thereby enabling all contributors or volunteers to access a particular VGI data production process.

(c) Endeavor to promote a well-organized data collection process.

(d) Be trustworthy and provide abundant information and supporting documentation.

(e) Include an emphasis, where necessary, on the value of collecting metadata and attribute information about objects.

(f) Should use accessible language and avoid excessive use of jargon and unnecessary technical, mathematical or scientific detail.

(g) Include methods that are transparent and clear.

(h) Be easy to adopt by citizens, i.e. require the use of well-known or easily understandable procedures to be performed with ordinary devices and tools.

(i) The protocol should emphasize the need to ensure that data collection is done in a timely manner.

(j) Ensure that the volunteers collect data with due respect to and regard for local laws and by-laws, personal health and safety, conservation and in respect of the local natural environment (Mooney, et al., 2014).

K. Producing VGI data (individuals and groups)

The key components of producing authoritative VGI data are:

1. Users

These are individuals or groups that crowdsource information about geospatial features around us. These people around the world are engaged with typing in their observations about the world. In this process, people could make mistakes, for instance, assign misleading tags to features or provide over simplistic boundaries for features (D'Antonio, Paolo, and Tomi, 2014).

2. Data

VGI data is produced using geospatial positioning, web mapping, cellular communications and wiki-based collaboration technologies. There are four fundamental characteristics of the data produced:

(a) Community based

This involves the collaborative engagement of large communities of participants in a shared project. The process entails diverse knowledge, abilities and interests.

(b) Fluid roles

There is the necessity to allow for a fluid movement of individuals producing data and playing different roles within the community.

(c) Common property

Members of the community are adopting more permissive approaches to legal and moral rights as well as intellectual property than those found in traditional content production (Coleman, Yola and Jeff , 2009).

Under data issues, there are also issues of:

(a) Data lifecycle management

Data lifecycle management is a policy-based approach to managing the flow of VGI data throughout its lifecycle. It ranges from the creation and initial storage to the time when it becomes obsolete and is deleted or archived. Data lifecycle management products automate the processes involved, typically organizing data into separate tiers according to specified policies, and automating data migration from one tier to another based on those criteria. As a rule, newer data, and data that must be accessed more frequently, is stored in faster, but more expensive storage media, while less critical data is stored in cheaper, but slower media.

(b) Data cycle management

The data cycle management service portfolio is designed to help the VGI production process to improve on efficiency and effectiveness through computerization, process improvement, performance management and analytics.

3. The web

The nature of data placed on the web will determine the maps to be produced and web mapping facilitates the sharing of geographic information via the Internet using free and open-source software (FOSS) and open specifications.

Other issues of concern on VGI are:

(a) Causes of errors in VGI data

Mistakes arising from our understanding and modeling of reality in the different ways in which people perceive reality can have different effects on how they model the world using VGI; the final product would be influenced by the personality and experience of the 'cartographer' and non-geo-information users.

(b) Errors in source data

Remotely sensed and aerial photography data could have spatial errors if it was referenced wrongly, and mistakes in classification and interpretation would create attribute errors.

(c) Opportunities in producing VGI data

The collection of GNSS-enabled VGI should follow a data collection protocol to ensure quality. Non-GNSS-enabled mobile devices must have fit for purpose accuracy protocols to guide quality and the use of phone features that enable collection of location information is imperative. Equally, armchair mapping from imagery sources should be fit for application/purpose. There is need for protocol to guide processing of the imagery—including the type of imagery suitable for different applications (imagery may come from public sources or from NMAs). Data collection from NMAs should be fit for purpose and requires a protocol. Metadata should always be captured and the capturing of non-spatial data can be done using simple devices / technologies (like sms). The use of social media to collect spatial and non-spatial data should be regarded as an opportunity in generating VGI data sets.

(d) Constraints of producing VGI data

National mapping standards need to be updated and correlated with international and regional standards. The harmonization of the different geodetic reference frameworks and the use of appropriate technologies and improved national regulations for NMAs is imperative as these issues have hampered the successful application of VGI in Africa. The data submitted by volunteers should endeavor to capture the persons collecting the data (basic information about the data collectors where applicable). Contributed data should not be uploaded until other data is received to support verification.

(e) Way forward in producing VGI data

It is important to prepare appropriate data quality specifications for different applications as well as encourage NMAs to adopt the African Geodetic Reference Frame (AFREF) and the International Terrestrial Reference Frame (ITRF) as national

references. Equally, the use of supplementary geo-referencing enhancement services available via mobile devices as well as inclusion CORS is required.

(f) Elements of spatial data quality

These elements during the production process are:

- Completeness: Presence and absence of features, their attributes and relationships.

- Logical consistency: Measures the degree of adherence to logical rules of data structure, attribution and relationships.

- Positional accuracy: Accuracy of the position of features.

- Temporal accuracy: Accuracy of the temporal attributes and temporal relationships of features.

- Thematic accuracy: Accuracy of quantitative attributes and the correctness of non-quantitative attributes and of the classifications of features and their relationships (Skopeliti, 2014).

L. Organizing VGI data (individuals and groups)

The application of VGI through the web platforms for information dissemination and exchange has revolutionized the organization of spatial data generated throughout the various stages of the VGI process. The organization of VGI has allowed users to add and upload geospatial-related data in GIS-enabled online sites thereby promoting geographic information sharing. There are websites implementing VGI through an organized manner; these include sites like wikimapia.org and openstreetmap.org etc. The new characteristics of VGI data need some new methods of organizing the generated data especially in data cleaning approaches. The VGI data correction process involves non-professionals in handling spatial data and the process should be guided in an organized manner through the applications used by users.

1. Elements to consider in organizing VGI data

(a) Updating the data

Since general users can add and change data, the stored data should be updated frequently, resulting in an abundant and updated geographic data set.

Data acquired by non-professionals with non-professional equipment lacks the guarantee of quality; contributors are spontaneous, the density of data is unpredictable, data distribution is uneven and inconsistent. These issues brought challenges for VGI data management, therefore new data cleaning methods must be used to solve problems like data clutter etc.

Data cleaning, including merge, delete and correct operations, makes it effective and consistent in form. In general, merge and delete operations can be achieved automatically; the correct operation requires some human user’s interaction to complete. Spatial information as well as attribute information must be taken into account in the geographic data cleaning like duplicated points finding and repeated description merging. There are several data cleaning methods for VGI data and their experiment results and some possible application environments in using these methods are discussed by various scholars (Qian, George, Liping Di, Pingxiang , and Deren, 2009).

2. Opportunities in organizing VGI data

The use of dropdown menus to minimize typing errors at the data collection stage is important. Equally, the application of an indexing method should allow easy retrieval and data analysis as well as the use of cloud technologies is encouraged.

3. Constraints in organizing VGI data

Data security concerns for the use of the cloud is a major issue in guaranteeing the confidentiality of the captured VGI data.

M. Analysis and presentation of VGI data

1. Assessing the quality of VGI data to be analysed

The quality of data has been the concern of many in the production of authoritative geographic data sets. High quality data is as a result of the application of standards and rigorous procedures in the geographic information production process. However, quality in volunteered geographic data sets has a different origin. Quality relies on the collective intelligence argument. This argument suggests that a large number of people editing a database are likely to produce, by consensus, data with higher quality than data created by a single editor (Lopez-Pellicer, Linked Map report on VGI data quality factors, 2012).

2. Methods and tools for analysis in participatory sensing

Semantic enrichment of VGI (mobility data)

(a) Locally at the smart device

(b) Bringing semantics to plain geographic information

(c) Semantics of mobility and events (ontologies)

3. Aggregation and fusion at servers (cloud)

(a) To improve the accuracy of reporting (sensing)

(b) Data stream processing

(c) To detect complex online events, behaviors, goals, etc.

(d) To generate notifications

4. Users generate and send semantic data

Users generate and send geo-information data related to their mobility by processing and analysing raw geo-referenced data in their mobile devices to servers (cloud).

5. Mobile devices in surrounding area

Various aspects of mobility of moving objects (people, vehicles, assets, animals) related to locations/trajectories (Stojanovi, 2014).

6. Opportunities in analysing VGI data

Submissions should be statistically analysed to ensure data reliability.

7. Constraints of analysing VGI data

VGI may not have a sufficient number of contributions for submissions. A decision on the minimum number of contributions should be made aimed at facilitating the analysis and interpretation phases of VGI.

N. Interpretation of VGI data

- **Personal**

Aspects to consider in assessing the quality of interpreting VGI data:

(a) Lineage

This feature of quality assessment is about the history of the data set, how it was collected and how it evolved.

(b) Positional accuracy

This is probably the most obvious aspect of quality and evaluates how well the coordinate value of an object in the database relates to the reality on the ground.

(c) Attribute accuracy

Assessments of the objects in a geographical database are represented not only by their geometrical shape but also by additional attributes. This measure evaluates:

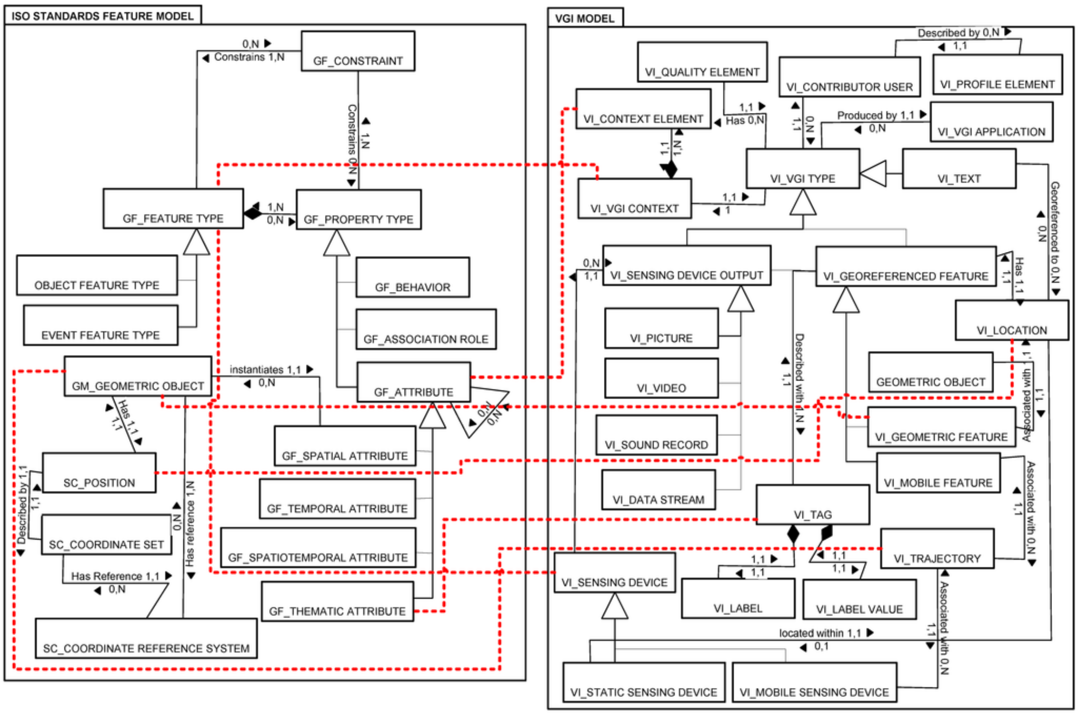
(i) Logical consistency: This is an aspect of the internal consistency of the data set in terms of topological correctness and the relationships that are encoded in the database.

(ii) Completeness: This is a measure of the lack of data; that is, an assessment of how many objects are expected to be found in the database but are missing as well as an assessment of excess data that should not be included.

(iii) Usage, purpose and constraints: This is a fitness for purpose declaration that should help potential users in deciding how the data should be used.

(iv) Temporal quality: This is a measure of the validity of changes in the database in relation to real-world changes and also the rate of updates (Haklay M. , 2009).

VGI Semantic Model and its relation with ISO 19100 series specifications.



Source: (Mohamed Bakillah, 2013).

O. Cognitive

VGI data analysis and interpretation is primarily a procedure to build understanding and, as such, it follows cognitive processes of the human mind. Data analysis tasks closely resemble the cognitive process known as sense making. VGI-generated data demonstrates how data analysis is a sense-making process adapted to use quantitative data. This identification highlights a universal structure within data analysis activities and provides a foundation for a theory of data analysis. The competing tensions of cognitive compatibility and scientific rigor create a series of problems that characterize the data analysis process. These problems form a useful organizing model for the data analysis task while allowing methods to remain flexible and situation dependent. The insights of this model are especially helpful for consultants, applied statisticians and teachers of data analysis (Grolemund and Hadley, 2014).

P. Data transmission for collected VGI data

VGI field data collection needs a file collection mechanism to collect and send data to the designed platform. Regular transmission of data from the field to platforms is vital for the management of data collected in the VGI data harvesting process and for early detection and resolution of potential problems. Equally, case assignment and application updates are very important issues that can improve logistical organization and data quality assurance within the VGI environment.

The transmission of data could be manual movement via flash drives or electronic file transfers depending on the approach used for data collection and existing network infrastructure. Also, monitoring the inbound flow of these files is important. The main data transmission modes are: full web model, flash-drives-based model, partial web model, card model and voice and SMS/Unstructured Supplementary Service Data (USSD). The transmission modes are considered carefully and the nature of the data will detect the transmission mode to be used.

1. Full web model

This transmission mode is a full network model that provides a web-based platform for monitoring the upload of field data. This mode requires access to the Internet for all actors. Users must be equipped with devices allowing connection to the Internet (access to wireless, wired or modem links to the Internet).

Users transfer collected data via Secure File Transport Protocol to the platforms. This data transmission mode is appropriate for face-to-face interviews using phones, laptops or tablets with electronic questionnaires that are linked to a device with geo-reference capabilities.

2. Flash-drive-based model

Data transmission is exclusively performed by use of flash drives like SD cards and USB keys. The functionalities of this mode are:

(a) Case assignment performed by use of flash drives.

(b) Users export data collected to flash drives.

(c) Data in flash drives is transferred to VGI platforms.

3. Partial web model

This model combines the Internet and flash drives like SD cards and USB keys. The difference with the previous model resides at the level of data transfer from supervisor to VGI platform. Instead of sending data in flash drives to platforms, data are transferred through the Internet via Secure File Transfer Protocol.

Q. VGI standards and data quality

1. VGI data context

In essence, VGI standards are agreed upon ways of managing voluntary crowdsourced data. The main focus is on managing spatial data as VGI standards cover a huge variety of activities undertaken by end users. VGI standards and data quality checks are generally applied to harmonize data content within the community. VGI standards generate organized knowledge and the powerful tools used help drive innovation and increase productivity of spatial data. The VGI data gathering process applies SDI standards in some aspects including, but not limited to, metadata and data quality assurance and services needed to ensure interoperability in a distributed VGI network. VGI has a broad user base of mostly non-professionals but SDI has a limited user base of mostly geo-information professionals (Castelein, Łukasz, Joep, and Arnold, 2010).

The general aspects of data quality include:

- Accuracy
- Completeness
- Update status
- Relevance
- Consistency across data sources
- Reliability
- Appropriate presentation
- Accessibility

VGI data quality is exaggerated by the way data is entered, stored and managed. Data quality assurance is the process of verifying the reliability and effectiveness of data. VGI data quality assurance from collection to databases should contain identifiable quality dimensions and quality metrics as an integrated process for ensuring the context of the data. Quantitative spatial data quality concepts (completeness, resolution, logical consistency, positional accuracy, temporal accuracy, temporal quality, thematic accuracy and semantic consistency) and non-quantitative quality spatial data concepts (lineage, purpose, usage and constraints) as well as the quality concepts unique to VGI data (believability, compliance and convergence) should be conducted as a prelude to VGI data analysis (Carlos Granell, Frank Ostermann, 2014).

Assessing the data quality of VGI is important in determining the fitness-for-use of VGI for different applications. This process should be accompanied by guidelines for good practice that may assist in quality assessment; in particular, recommendations on additional data that could be used and procedures that could be implemented to facilitate the assessment of VGI quality. Finally, the role of protocols is imperative, aimed at improving data quality assessment.

2. The context of VGI standards

The context of VGI standards addresses data management issues related to completeness, which investigates and measures the extent to which the lack of data or excess data in the database affects the outputs generated from VGI in decision-making. The resolution and other components of VGI data measure the amount of detail that can be discerned from the data as well as the logical consistency investigated and also measure the absence of logical contradictions in the VGI database. More so, the context of VGI looks into the positional accuracy of the spatial data, and measures the level of deviation of the points in databases from the actual location in the real world. The temporal accuracy of VGI data measures the agreement between encoded and actual temporal coordinates. The temporal quality measurement gauges the degree to which a database is up-to-date in relation to real-world changes. The thematic accuracy helps in measuring the correctness of values and their assignment to feature classes. The semantic consistency measures the matching between the meaning of database objects and the meaning in real-word objects.

3. The context of VGI data quality

There are several dimensions of data quality assessment in terms of quantitative dimensions shared with geo-information (completeness, resolution, logical consistency, positional accuracy, temporal accuracy, temporal quality, thematic accuracy and semantic consistency), non-quantitative dimensions shared with geo-information (lineage, purpose, usage and constraints) and dimensions exclusive for VGI (believability, compliance and convergence).

VGI data context enables users to clearly define their requirements in terms of faster updating cycles, the requirement to gather additional attribute information, reduced funds available for in-house production, or the strong need to involve the user community for other reasons. Alternative approaches involving VGI may then be objectively assessed and compared in terms of characteristics, strengths and weaknesses.

4. VGI data content

Knowledge of the VGI data content enables users and other key stakeholders in the VGI data harvesting process to have control over the content and other data quality issues. The process of decision-making regarding the reliability of the data is established after determining the content of the data to be collected. The extent to which the content of the data is controlled is held by the contributor, by the institution, or by “the crowd” of contributors assessing each other's contributions (Coleman, 2010).

R. The content of VGI data quality and standards

1. Positional quality

(a) Positional quality and data standards

Assessing the content of the positional quality enables the assessment of positional consistency in the data sets. This information may be used to conflate data as it has been demonstrated that positional accuracy of data collected from roads through OpenStreetMapping (OSM) improves with an increase in the number of contributors illustrating that Linus’ Law applies here. The law assumes that as the number of contributors increases so does the quality of the VGI data within the open-source community (Haklay, Sofia , Vyron, and Aamer, 2010).

(b) The content of stored historical data

Stored historical data would enable the identification of change and assess the stability of positional information over time. This identification of changes generally improves the quality of the data collected over the years.

2. Metadata development on the methods used

(a) The nature of the image

Spatial resolution and spectral composition will provide information about the volunteer’s difficulty in identifying the features and the accuracy of the obtained position. This stems from the fact that most contributors do not have geo-information background.

(b) The time of image collection

The year, month, day and even time of day, may give information about the season which may influence the vegetation, phenology, degree of human occupancy in tourist regions, the amount of traffic depending on, for instance, whether it was rush hour or not, the amount of light, the direction of shade in the image, etc. Knowing the time of image collection drastically improves the nature and depths of analysis to be conducted using VGI data.

(c) Identifying whether specific instructions were given to the volunteers about where to locate the features is important in identifying errors and correction measures to be conducted in the data. Ideally, information regarding where to place the photographs should be provided, including the location from which the photograph was taken and its orientation. Other information regarding points of interest should also be specified, for instance, whether the points correspond to the building centroid or to the entrance of the building that gives access to the point of interest.

S. Positioning over a map

This encompasses several issues such as:

1. The type of map used

A map can be made by volunteers, it could also be a thematic map, a topographic map created by a national mapping agency etc. The accuracy of the geo-referenced data is important to ensure that the data digitized aligned accurately with other data sets.

The map scale and/or the minimum mapping unit

This provides a measure of the maximum precision attainable. A unique scale has to be used consistently with all the layers determined.

2. The date of the map

It’s important for determining the currency of the data. The data will facilitate the determination of changes over time.

3. Positioning using GNSS measurements

The measurement is made automatically when the data are collected and uploaded, for instance, when taking a picture and uploading an EXIF file. The positional data is collected separately and uploaded later, which is less reliable. Additional information to assess quality, which would be useful if recorded, includes: (a) The type of Global Navigation Satellite System (GNSS) receiver used; (b) The number of measurements used to determine the location; (c) The date and time of the measurement, which enables the determination of the dilution of precision associated with the measurements; (d) The number of satellites used for positioning.

4. Conflating data provided by volunteers

The conflated VGI data will depend on the following conditions: (a) The amount of data for a given feature that has been used to obtain the indicated location; (b) The degree of variability of the data used to determine the most probable value; (c) The dates and times associated with the collection of data about a particular feature; (d) Interested users can be provided with access to the raw data.

5. Thematic quality

The quality control of thematic data may be facilitated if some procedures are implemented during the data collection process such as:

- Collecting information from multiple contributors.
- Checking the consistency of the data
- Assigning a label through the conflation of data, whenever divergent data are provided, using, for example, latent class analysis.
- Asking volunteers for a confidence rating with tags.
- Keeping historical information for the same reasons as outlined earlier for positional quality.
- Indirect information about the confidence of the volunteer in the assignment of the tag or label may be obtained by:
  - Collecting additional information such as the amount of time taken to assign a label.
  - Whether the volunteer used instructions or consulted training materials between assessing a point and providing a label.

6. Other useful metadata

- The prevailing atmospheric condition at the time of data collection, which may be relevant for the collection of biological or environmental data.
- Additional data for photographs that may be useful for applications in land cover /use mapping includes:
  - The orientation of the photograph.
  - A description of whether the surrounding area is homogeneous or heterogeneous.
  - The date the photograph was taken.
  - Data about the exposure of the photograph and the type of camera used.

T. Guidelines for assessing volunteer credibility

Volunteers’ expertise may be assed using metadata about the volunteers. The metadata could be about:

- Education
- Profession
- Interests

U. Volunteer’s trustworthiness

It may be assessed using:

- Use of control information such as test sites where information provided by experts or selected volunteers is available, which can be used to assess the contributions of each volunteer.
- Use of historical data provided by the volunteer such as the number of times their contributions were corrected by other volunteers, selected volunteers or experts.
- Use of information about where the volunteer is located. The assumption is that the closer a volunteer is to the location of the data that was uploaded by them, the more reliable the data will be.

V. Generic good practice guidelines

Some general practices may be implemented that can contribute to the production of more reliable information such as:

1. Implementing automatic means to check the data

- Using additional data or metadata and making an automatic check of whether the data provided are likely to be correct.
- Enabling volunteers to identify erroneous contributions (regarding positions or attributes). This may provide valuable information about:
  - The contributor
  - Difficulties in assigning classes
  - The credibility of locations of phenomena.

It’s important to enable discussions among the volunteers whenever difficulties are experienced such as the best class to assign to a particular location. This may enable the sharing of locally-relevant information; improve the understanding of ontologies; self-correction and quality control.

W. The role of protocols

- Strict protocols for data collection are used in some areas of citizen science projects. However, in other projects, contributors choose what to map, how and which tags they use. This means the quality of data is more difficult to assess.

- The establishment of protocols may, on the one hand, provide valuable information that may make the data useful for additional applications. However, very demanding protocols may de-motivate the volunteers from contributing.

- A balance needs to be identified so that protocols are not seen as restrictive but, rather, a way to help users in providing higher quality data.

Quality assessment of VGI remains one of the most important issues for determining the fitness-of-use of VGI for different applications. Some good practice guidelines are presented here that may provide valuable information to assess the positional and thematic quality as well as the volunteers' and data credibility, enabling its potential utilization for a wider range of applications. However, the implementation of some of these guidelines may require the definition of protocols for data collection, which has advantages and disadvantages, and therefore needs to be defined with caution (Cidália C. Fonte, Lucy Bastin,Linda See,Giles Foody, Jacinto Estima, 2014).

V. Chapter Five

A. Community engagement for VGI data quality and standards

Geospatial data through VGI is created by and shared for free by the VGI community. The community ensures that the data possess quality and respect standards following laid down protocols. The capability of affording community groups and members opportunities to use digital or analog spatial objects to express views on phenomena affecting their communities is important. These expressions of local knowledge have augmented, complemented or verified governance decision-making processes.

There are various kinds of collaborative communication channels in the VGI community that ensure data quality and standards. VGI for community preparation has received less attention over the years and this has resulted in poor data quality and use of standards. The potential role for VGI to foster community engagement needs to be assessed and collaborative information channels developed (Michael Sutherland, Titus us T, Amit S, Bheshem B, Susan N., 2012).

B. Specific collaborating channels for VGI geospatial information

- Social media are Internet-based applications that enable people to communicate and share resources. These act as collaborative channels for VGI geospatial information. Proper application of standards through channels will ensure reliable data for VGI analysis and decision-making.

- Online map-making software open to public contributions (e.g. Ushahidi Crowdmap, OpenStreetMap).

- The use of devices such as smartphones, which enable collection, creation and sharing of data in unprecedented ways.

Thus, communicating information is needed; but not only information communication from agency to citizen, but from citizen to agency and between citizens. Approaches that augment traditional processes of information dissemination and reception and facilitate collective, two-way and integrated systems of sharing local and authoritative knowledge may create a wider understanding (Billy Haworth, Eleanor Bruce, Peter Middleton , 2015).

C. Customization of VGI data quality and standards

VGI websites facilitate the creation, assembly and dissemination of user-generated content. On the base maps provided, users can define their own content based on firsthand knowledge of local geography. The content of interfaces has to be customized not only to generate data but also to ensure data quality and respect of standards.

- **Content customization for the user**

- Content customization incorporates VGI-supplied information such as links to online photos, websites, Geo-Really Simple Syndication (RSS) feeds, tweets and YouTube videos that are combined with authoritative base-map data that includes streetmap coverage, satellite imagery, topographic maps, navigational charts and data on environmentally-sensitive sites. Visitors can place new information on the map by choosing a feature icon, clicking on the map and linking to the content to be added.

- All sites that depend on user-generated content must motivate people to act voluntarily. Contributors need to understand how the content they collect supports the site's overall goal. Also, sites that let end users enter information must be managed by an administrator to ensure that the content posted is credible, relevant and not offensive in substance or language and to avoid copyright infringement issues. When end users have been successfully motivated and are contributing to the map, administrators filter the map's geometry to avoid clutter that could make the map illegible. This eventually ensures data quality and standards (Bronwyn Agrios, Keith Mann, 2010).

D. Communication as a component of VGI data quality and standards

The communication channel used in the VGI data generation process refers either to a physical transmission medium such as a wire, or to a logical connection over a multiplexed medium such as a digital channel. A channel is used to convey VGI information, for example, a digital bit stream, from one or several senders (or transmitters) to one or several receivers. A channel has a certain capacity for transmitting information, often measured by its bandwidth in Hz or its data rate in bits per second. Communicating data from one location to another requires some form of pathway or medium. These pathways, called communication channels, use two types of media: cable (twisted-pair wire, cable and fiber-optic cable) and broadcast (microwave, satellite, radio and infrared). Cable or wire line media use physical wires of cables to transmit data and information. Twisted-pair wire and coaxial cables are made of copper, and fiber-optic cables are made of glass. Therefore the strength and penetration of communication channels in a country will invariably determine the density and quality of the VGI data to be generated by users. Users with small Internet bandwidths will find it difficult uploading huge satellite images before digitization. The protocol established to generate a particular type of VGI data should clearly indicate the information technology components or specifications.

Site-to-user communication channels exist , for instance, Really Simple Syndication (RSS), blogs etc. Several site-to-user communication channels have been established with the advent of the Internet and mobile technology. Web 2.0 is a term used to describe advanced Internet technologies and applications that enable collaboration and information sharing. Some of the popular Web 2.0 technologies are blogs, social networks and RSS. The use of these tools has not only popularized VGI but has also improved the quality and standards of data being generated.

The major challenge of Web 2.0 technologies has been the rise of social media. Social media are the online platforms and technologies that people use to build social networks by communicating with others and sharing experiences, opinions, insights and perceptions. Social media not only include text, but also images, audios and videos. Therefore the growing interest in social media has greatly limited the use of other Web 2.0 technologies thereby limiting the quantity of data generated for VGI purposes.

E. Connection as a determinant of VGI standards and quality

Several external factors related to connectivity influence the generation of spatial data through the VGI process. VGI, mapping mashups, virtual globes, ubiquitous computing, locative media and location-based services are strongly related to connectivity. Social networks, wikis and crowdsourcing are terms used from a geographical perspective. The reliability of the data being generated will determine the interest in collecting this type of data, so it is essential for standards and quality assurance measures to be put in place to build trust in the user community thereby promoting the generation of more VGI data.

The external content links to sites is important in determining the degree of connectivity in the VGI data generation processes. Web pages with content for VGI should be under the direction and control of the VGI individual or group of users to ensure data quality as well as monitor the application of stipulated standards by users.

The purpose of controlling the external content of VGI public sites is aimed at encouraging efficiency, convenience and cost effectiveness in the maintenance of the sites and promotes the continuous generation of spatial data through the various sites.

F. Commerce as a component of VGI data quality and standards

The amount of commercial transactional service available is important in the sustainability of the VGI process. The commercial transactions involved help in the sustainability of sites as well as in the improvement of the content in the sites. High resolution images through this process can be acquired to improve the quality of the data being generated.

Data ordering services or free downloads should be regulated as defects in the order process often lead to orders making a loss, certainly with the traditional high order volumes and low order values caused by Internet-based sales. The order process should be fully dependent on the nature of the data. Data specifications should be clear with metadata information attached to the acquired data. It has to be noted that data ordering services have limited applicability in VGI due to the volunteered nature of information.

G. Collaboration to improve VGI data quality and standards

The use of VGI as a collaborative platform for the publishing of maps has made it interesting in seeking views and updates on the ground, especially as it provides visual accompaniment and guidance in decision-making. The services provided by VGI enable collaboration amongst users through the use of common technologies—easy access extensive help and support resources provided by a creative, commons license process. This collaborative approach alternately enhances the quality of data for precise decision-making.

H. Collaborating in geospatial content

Developed platforms have been used for collaboration and specification enabling users to create and make available their own VGI. Extensive help and support resources—both official and unofficial are required to make this process effective.

I. Credibility to enhance VGI data quality and standards

Contributions of data and time of updates are essential for ensuring credibility from contributors. Account registration logs of all changes and time stamps should be provided freely. The credibility of the volunteer may be used as an indicator of the reliability of the data provided. Volunteer credibility may be separated into volunteer expertise and volunteer trustworthiness. A volunteer's expertise may be assessed using metadata about the volunteer such as age, education, profession or interests. To assess the volunteer's trustworthiness, a range of approaches may be used including: (1) Use of control information such as test sites where information provided by experts or selected volunteers is available, which can be used to assess the contributions of each volunteer; (2) Use of historical data provided by the volunteer such as the number of times their contributions were corrected by other volunteers, selected volunteers or experts; (3) Use of information about the volunteer's location (Cidália C. Fonte, Lucy Bastin,Linda See, Giles Foody, Jacinto Estima, 2015).

Spatial data collection, processing, publication, analysis, distribution and understanding have traditionally been handled by professionals. However, as technology advances, more spatial data are needed for an increasing number of applications. By using technological and web developments, non-experts can now collect geographic information. Professionals are striving to update their data sets in an environment of increasing competitiveness and reduced funding, and these new crowdsourced data options that seem to be threats can also be opportunities if appropriately handled in aspects including, but not limited to, data quality and standards (Koukoletsos, March 2012).

1. Opportunities for applying VGI quality and standards

There are international, regional and national standards. To ensure credibility — correlation with other VGI data sets (where available)— avail tools that perform automated checks of data and ensure that other contributors check the data, use of preliminary checks before data is uploaded etc.

2. Constraints in applying VGI quality and standards

There is need to harmonize standards and make them readily available as well as deal with the incompatibility of geospatial standards. The cost of geospatial standards should be previewed and avenues for funding developed. Resources should also be allocated for training. Unfortunately, there is limited African participation in the development of international geospatial standards and there are also limitations for Africans to discuss geospatial standards (at national, regional and continental levels).

3. Way forward for applying VGI quality and standards

There should be harmonizing of the standards and making them available. Setting funding kitties for geospatial standards should be a priority and also ensuring the availability of metadata standards. There is a standard under development for geospatial data archiving (19165: Geographic Information – Preservation of Digital Data and Metadata. This draws/borrows from ISO 17421: 2012 Space Data and Information Transfer Systems – Open Archival Information System (OAIS) – Reference Model.

J. VGI data dissemination

The emergence of VGI has created a new platform for the collection and dissemination of geospatial information. Authorities can now rapidly communicate important time-critical-information directly to the public at a fraction of the logistical and resource costs of traditional communication methods. Sharing content online facilitates fast and broad information mobility. VGI collection and dissemination through social media, in particular, has an inherent ability to promote or propagate messages (Haworth and Eleanor, 2015). Technology has enhanced the dissemination of VGI data leading to the generation of unprecedented volumes of geospatial data, giving rise to the paradigm of big data (Bakillah, 2013).

1. Dissemination systems in VGI

In building a VGI dissemination system, certain considerations should be made such as: (a) storage and distribution of fundamental data sets; (b) deploying and supporting VGI web mapping applications; (c) VGI support and customer satisfaction. The intention of VGI data dissemination in raster and vector formats is to increase the user base. Equally, the dissemination system helps in the development and maintenance of methodologies and procedures for keeping the VGI data sets current. This helps create multiple solutions for enabling VGI users to utilize various VGI tools and methods to retrieve data. The system helps to provide a superior level of support to users concerning VGI data sets and VGI applications and tools.

2. VGI dissemination application servers

- Multiple Windows servers running and used to serve data & services to facilitate the VGI data dissemination process.
- Development, staging & production servers supported by VGI users to ensure access code is successfully deployed between environments.
- Multiple servers to test operating systems and software upgrades.

- Customer support to users of the map geodatabase, file system and web mapping applications.
- Multiple methods for customers to interact with VGI database administrators to obtain support.
- No pre-processing of data required—this creates seamless data sets of imagery.
- Improved scalability and performance; requires less bandwidth to distribute data.
- Reduced load/index time of imagery.
- Ideal for remote sites with limited network resources.

K. Current trends in VGI dissemination tools

1. (Spatial) Databases

(a) SQL

SQL stands for structured query language and is an international standard defining a language for querying relational databases. While there are issues between implementation of SQL between different VGI users, mostly over time and date values, SQL has proved to be very successful. By using SQL, external programmes are able to abstract many of the issues of accessing databases to allow users to choose the database they prefer to generate spatial data. It also defines a set of functions for manipulating and querying geometries.

2. Relational databases

(a) PostGIS

It is a free and open-source extension to the popular PostgreSQL database. It provides full simple features for SQL support. Here is a link to the latest version of PostGIS (link is external). PostGIS has an excellent feature set, high reliability and free licensing.

(b) The SQL server (Microsoft)

The SQL server is Microsoft's premier database offering a database solution (link is external). It is one of the "big three" commercial Database Management System (DBMS) along with Oracle and DB2. It often provides the back-end solution for large VGI installations.

(c) Oracle Spatial and Oracle Locator

Spatial and Graph (link is external) are the spatial extensions to the popular, powerful and expensive Oracle database. They provide simple features for SQL compliance for types and features, but not import and export of Well-Known Text (WKT) or Well-Known Binary (WKB). Oracle was first in coming out with good spatial support, but the extent of its implementation in VGI has to be investigated. The DB2 Spatial Extender (link is external) allows one to store, manage and analyse spatial data in IBM's DB2 database system. The spatial extender implements the Open Geospatial Consortium (OGC) Simple Feature Specification.

(d) SpatiaLite

SpatiaLite is a spatial database based on the popular lightweight SQLite (link is external) package; a self-contained serverless transactional SQL database engine. SQLite is an open-source software and its public domain nature has helped its uptake. SpatiaLite (link is external) is compliant with the OGC Simple Feature Specification (except for renaming union to gunion—due to a reserved-word clash). Some commentators (link is external) have predicted that SpatiaLite may finally replace the Shapefile as a data-exchange format.

(e) MySQL

MySQL claims to be the world's most popular database but its spatial extensions (link is external) are only a subset of the Simple Feature Specification. All of the functions that calculate relations between geometries are implemented using bounding boxes, not the actual geometries.

(f) Other databases (NoSQL)

In recent years, there has been a trend of using the so-called “NoSQL” databases. This is a loosely-related set of databases that are non-relational, distributed systems that often don't provide an ACID guarantee. ACID (link is external) stands for atomicity, consistency, isolation and durability, which are all great things to have when one is considering a banking system (one would hate to see money disappear from their account but not reach the payee's account) but are considered unnecessary for some modern applications.

(g) Facebook comments

There are, as yet, no full spatial extensions for these databases, but a number provide a variant on the geohash solution. Geohashing is a way of converting a spatial location into a single text key [see the Geohashing wiki (link is external) and Google Maps API (link is external)]. The other solution adopted by some of these systems is to use a spatial SQL database as a back-end for spatial queries.

(h) Analysis of the impact of ever-changing technologies on VGI dissemination

There are three main challenges for disseminating VGI data sets; its sheer volume, its deficit of clear structure and its lack of quality control. The amount of VGI has increased tremendously over the past years, and with the introduction of GPS receivers in smartphones and digital cameras and widespread mobile Internet access, we can expect this development to continue for years to come. The heterogeneous media formats and interface options of the various social media platforms lead to a wide variety of possible data structures. This problem is aggravated by the lack of syntactical control over the data entered by users and by the ingenuity of users and software developers able to overcome device or interface limitations.

(i) Opportunities in VGI data dissemination: Use of cloud computing and dissemination of data via web geo-portals are opportunities to be used. It is important to ensure that contributors have access to the final product and the use of social media for the sharing of the results is imperative. The integration of electronic and print media present themselves as opportunities. Meanwhile, there is the necessity to encourage policies to support availing results of publicly-funded projects.

(j) Constraints of VGI data dissemination: Data security concerns for the use of the cloud, language, format and capacity to effectively use the information coming via VGIs are some of the major constraints impeding VGI data dissemination.

(k) Way forward in VGI data dissemination: Provision of mechanisms for capacity building and the use of simplified technologies to support wider usage of VGI data should be encouraged.

L. Publishing VGI harvested data

- **Publishing geolinked data on the Web**

The process of publishing is based on the following activities: (a) identification of the data sources; (b) generation of the ontological model; (c) generation of the data; (d) publication of the data; and (e) linking the data with existing other data sets in the cloud (Vilches-Blázquez, Boris , Alexander , Freddy , and Corcho, 2010).

Examples of data sources:

- SHP
- SDF
- SQLite (FDO)
- SpatiaLite
- PostGIS
- Oracle Spatial
- Microsoft SQL Server Spatial
- MySQL
- Any other FDO vector data source

Example output formats:

- GeoJSON
- XML
- OData
- PNG (MapGuide layers only)
- HTML (Template)
- KML (Template)
- GeoRSS (Template)
- CSV (Template)
- Any other templatable text-based format

VI. Chapter Six

A. Sharing VGI harvested data through SDI

By connecting VGI geospatial data and service producers and consumers, infrastructure and costs can be kept economical. The VGI technology is scalable and can fit into any infrastructure, including existing geospatial technology installations. It enables easy search and discovery of existing geospatial data and services. Users can create and post metadata records efficiently, which are necessary components for inventorying, locating and assessing the quality of geospatial data. The system should maintain data integrity and security.

SDI has evolved to enable geospatial information sharing at a significant scale. VGI provides mechanisms for posting, discovering, evaluating and exchanging existing geospatial resources in support of both broadly-based SDIs and narrowly-framed local and organization-specific data-sharing communities.

Organizations can improve knowledge sharing, reduce duplication of effort, direct people towards the best available data and improve the overall quality of geospatial data and information.

- **Enabling platforms of VGI**

VGI platforms sharing up-to-date information by making use of VGI requires systems that can be understood, accessed and also referenced by different data users. Information is shared through the VGI systems retrieved from multiple sources based on different parameters such as spatial and temporal. Further, different platforms will be used to store, publish and disseminate VGI, and at the same time locate and query, ready for its processing in a way that it will be understood and made use of. Most of these platforms employ Web 2.0 technologies (Goodchild, 2007a; Elwood, 2008a; Hudson-Smith et al, 2009). The different platforms on which VGI is presented include geospatial browsers, wikis, mashups and folksonomies.

VGI and Traditional Data Collection Methods VGI Enabling platforms, Components and Database Management Tools				
VGI and Traditional Data Collection Methods	New elements of VGI introduced that differ from the traditional methods of data collection	**Technology** • Consumer mobile devices(with location capability) • Communication channels (SMS, GPRS, USSD) • Social media platforms • Geo-referenced content **Human Resources (Skilled/Amateur)** • Organized/coached contributors • Ad hoc contributors Local knowledge	**Technology** • Uneven distribution of cellular coverage • High data costs • Limited bandwidth • Disparity between rural/urban areas • Exposure to risk **Human Resources** • Limited geo and web skills • No guarantee of availability • Contributing to VGI is a lower priority **Local Knowledge** • Unethical collation and sharing of local knowledge • Infringement of IP rights • Selective/biased contribution	**Technology** **Human Resource** • Develop basic guidelines/tutorial on procedures **Local Knowledge** • Comply with code of ethics
	Advantages of traditional	• Well documented procedures		

	data collection methods	• High end technology used		
	Disadvantages of the traditional data collection methods		• Time consuming • High cost	
VGI Enabling Platforms Components, and Database Management Tools				
	Emerging VGI Enabling platforms, components and Database management tools present	• Web 2.0 technologies • Social Media (Location enabled) • FOSS	• Difficulty in integrating social media data	
	Advantages of emerging VGI enabling platforms, components and database management tools present	• Large contributor base • Remote collaboration/contribution • Anonymity (whistle blowers)		
	Disadvantages of the emerging VGI enabling platforms, components and database management tools present		• Lower data quality • Moderation required • Little/no metadata • Malicious contribution/dis-information • Privacy Infringement • Anonymity	

Source: Expert Group Meeting on Volunteered Geographic Information (VGI) Regional Centre for Mapping of Resources for Development, Nairobi Kenya, 21-22 November 2015.

B. Geospatial browsers

These play a big role in managing knowledge, structuring workflows within and across organizations, and communicating with like-minded individuals in virtual communities (Scharl and Tochtermann, 2007). The enabling technologies for the geospatial web are geobrowsers such as NASA World Wind, Google Earth and Microsoft Live Local 3D. These three-dimensional platforms revolutionize the production and consumption of various media products such as web pages, photos, podcasts and videos that could be geo-tagged to some reference information such as geo-position. They not only reveal the geo-positioning of web resources and services, but also bring together players of similar interests, culture browsing behaviour, or geographical distribution.

1. Wikis

Wikis enable a group to access and edit content at any time by any number of people. This open system is integral in facilitating collaboration and content sharing, but subsequently offers little in defence of site vandalism. The wikis' only defense against inaccurate data boils down to trust in the collective wisdom of the crowd for self-regulation (Bishr and Kuhn, 2007). OpenStreetMap is an example of a wiki application in VGI.

2. Mashups

A mashup is a web application that acquires content from different sources to create one service displayed as a single interface. In VGI, mashups combine content from other sources like mapping data, web services, feeds and geo-referenced data to create a new data resource in a web interface, and largely uses the Extensible Markup Language (XML) to transfer data (Pietroniro and Fichter, 2007 in Li and Gong, 2008). It is the action of this cumulative element that enables information to be reused and reinterpreted to suit the specific needs of its user. Some mashups use an interface such as a widget, to enable the user to dynamically interact with the underlying data (Crupi and Warner, 2008). Mashups provide an effective way of engaging with the significant volume of information in VGI. They allow the user to tailor the content in order to produce ad hoc solutions that address short-term needs. Mashups are flexible and easy to customize to the required user needs.

3. Folksonomies

Folksonomy is a way of identifying items by application of tags on those online items. It is a user's method of defining data. They consist of three basic entities; users, tags and resources. Users create tags to mark resources such as web pages, photos, videos and podcasts. These tags are used to manage, categorize and summarize online content as would be the case in a VGI platform. This collaborative tagging system also uses these tags as a way to index information, facilitate searches and navigate resources. Folksonomy also includes a set of Uniform Resource Locators (URLs) that are used to identify resources that have been referred to by users of different websites. These systems also include category schemes that have the ability to organize tags at different levels of granularity (Vander-Wal, 2004).

C. Components of a VGI platform

With the emerging technologies and research being undertaken by different players both in GIS and ICT, it is impossible to have one defined way or infrastructure of enabling VGI platforms. However, there are components that must always interact in order to achieve the goals of implementing any form of a VGI platform. In general, a VGI can be thought of as having three main sets of components:

1. Data store components

This is where data is stored and published. It is the foundation of VGI. In the data layer, a central database server is configured to receive and maintain all necessary data. Choosing the database and how it is structured is a huge part of VGI design. The data layer is usually defined within a spatial DBMS after the conceptual modelling for the VGI application.

2. Analysis/business components

Analysis components are all the things that happen between reading the records from the database and having everything rendered to screen; this could be the web service provider and a metadata catalog server that offer data access that goes beyond the need of the VGI application itself, organizing access to the underlying data tables. Every computer program has an implicit or explicit model realized in how it encodes and manipulates data. A VGI should have a rich spatial data model (and increasingly, a rich temporal model).

3. Presentation components

This is the point at which the VGI product interacts with users; if one can't provide information to users, available as maps and other data graphics, all the database and analysis components are useless. The presentation layer also contains the elements and components that are responsible for data collection. It is the layer on which the user interacts with the VGI platform, either as Web or mobile.

To achieve the above ecosystem of the three inter-twined components, a careful analysis of both hardware and software needs to be put in place. Various platforms are used to gather user-generated spatial content for specific themes. However, the structure and working mechanisms of these tools is quite similar.

4. Infrastructure

The collection, production, management and analysis of data across the VGI data value chain require some technical infrastructure that may be unique from one platform design to another. Though the general conceptual design may look alike from one platform to another, the kind of hardware and software components will vary from one system to another. The ultimate composition and kind of software and hardware required largely depends on the desired final product and the supporting technology. However, these are the basic components that every VGI platform should carry, regardless of the configuration, location or platform on which it is developed.

5. Server and client devices

Whether it is in the cloud or grid-setup, VGI services will need to be run and hosted somewhere. This brings the issue of the client-server relationship in which the server provides feedback to the client requests. These range from the computing platform on which developers operate from. This is especially on the client side on which developers can develop applications and at the same ends where users interact with the VGI platform.

D. Location-based devices and data collection tools

These devices aid in data collection and location detection. They include GPS units and smartphones. Users in turn feed the data into the VGI platforms passively or actively. For instance, in OSM when a user uses GPS to map a road, that is passive usage but when he relies on active geodata to clean the GPS input and add the correct input then he is actively involved.

Geo-tags are other codes that are dynamically attached to information so that its appropriate geographic position can be known. They also enhance identification metadata. Such information could be podcasts, videos and pictures on, for example, flickr and other web sites. The data that may be of importance would include geo-data such as latitude and longitude.

As much as smartphones can be used for geo-tagging and other location-based services, they can also be used to gather on-the-ground knowledge by using Short Message Service (SMS) and Twitter, such as the technology employed by the Ushahidi platform that was used to monitor chaos during the 2007 post-election violence in Kenya and subsequently used to manage disaster during the earthquake in Haiti in 2010.

1. Broadband communication

Broadband is the ability of a transmission media to transmit multiple signals and different types such as video, imagey, text etc on high-speed media. The use of GeoWeb and the application of VGI, which requires real-time or almost real-time data transmission, requires high-speed data connectivity. This is because, for instance, Web 2.0 technologies and VGI services are resource intensive. Thus, the media or communication channels that would be required for this communication would be optic fibre, coaxial cables, twisted pair and now with the 3G and 4G technologies, there is mobile broadband. Traditionally, it would not have been feasible to implement VGI platforms to match the needs they are used for today if people used the baseband technology that had a limited support for services and only enabled only one-way flow of information, limiting participatory engagement.

2. File/database server

Traditionally, this was set up as a dedicated physical server running a server operating system and a DBMS software. It is used to service requests of other clients, which could be physical client computers or even programs. Today, these services have been implemented in the cloud as Platform as a Service or Software as a Service. With advancement in technology, these client services can also be availed from the cloud without having the need to invest in a physical box, and considering VGI employs a lot of participatory and voluntary operations, a VGI framework would work better if requests are being sent and responded to without concern of where they are being stored or retrieved from.

E. Software and tools

The software that enables the use of VGI can be both proprietary and FOSS. There are dozens of software options that different VGI products have been developed on.

1. Software development tools

These are tools that can also be programs that programmers use to design and develop new programs and applications. They can also be used to debug and maintain existing applications. VGI platforms have been designed using a wide variety of software development tools, some of which are proprietary and others are FOSS. For instance, OSM was designed using FOSS and a combination of other tools. There is no universally accepted tool when it comes to designing VGIs. There could be a myriad of tools applied in coming up with one product. Esri recommends developer tools such as HTML5 and JavaScript for ArcGIS.

2. APIs

An API can be deemed as a set of routines, protocols and tools for building software applications. API specifies how software components should interact and APIs are used when programming graphical user interface components. A good API makes it easier to develop a program by providing all the building blocks. A programmer then puts the blocks together (Vangie Beal, 2000). Depending on the VGI framework used, there are different APIs that enable communication and interaction with other services and applications. They help VGI applications in powering map data to websites, mobile apps and hardware devices. Apart from that, they offer many other tools for manipulating spatial data (editing, updating, enhancing, qualification).

As a result, any user can build up maps that are personal (static or dynamic) and customizable (feature implementation, scale, type of data) with any type of data (Stephaney Roche, 2013). The practice of publishing APIs has allowed web communities to create an open architecture for sharing content and data between communities and applications. In this way, content that is created in one place can be dynamically posted and updated in multiple locations on the Web. For instance, content can be dynamically posted. Sharing live comments made on Twitter with a Facebook account, for example, is enabled by their APIs. There are other APIs by Esri such as ArcGIS API for JavaScript that supports the latest enhancements in HTML5 and JavaScript, ArcGIS API for Flex that supports rich Flex components such as data grids, trees, panels, and charts and ArcGIS API for Silverlight that leverages popular Microsoft languages and platforms (Esri Web).

F. Spatial database

The main functional elements across the VGI data value chain include data input/capture, management, data analysis, information exchange and presentation. This data needs to be stored somewhere so that it can be accessed/retrieved and processed as required in order to meet the objectives. A database (whether physical) or cloud, as a platform as a service, is necessary to hold this data. Data is stored and accessed in different formats, in near real-time, depending on the desired purpose. Different options need to be given careful considerations with functionalities, pros and cons being carefully analysed while maintaining logical consistency. Databases should also be properly designed so as to reduce inherent data quality problems including, but not limited to, completeness, logical consistency, positional accuracy, temporal accuracy and thematic accuracy.

1. GeoWeb technology

This is the compilation of hardware and software that enables web mapping. It is the centre of the revolutionalization of VGI. It is a collection of online location-enabled services and infrastructure. It provides data or computing resources for client applications. It is especially characterized by high interactivity and geolocation-based contents generated by users. It is a large, widespread, distributed collaboration of knowledge and discovery that promotes and sustains worldwide sharing and interoperability (Dangermond, 2015). Examples include GeoFRED. They also provide system adaptability and portability, and extensibility for user-sided application purposes.

2. Web 2.0 technologies

These Web 2.0 technologies facilitate engagement with VGI by enabling collection, organization and sharing of geographic information. Importantly, they promote cognitive and social interpretation of VGI (e.g. Goodchild 2007a; Hudson-Smith et al, 2009; Elwood, 2008a; Flanagin and Metzger, 2008; Szott, 2006 in Graham, 2009; Tulloch, 2008). They provide a two-way interactive mechanism between data collectors and the interface itself. These are used in implementing frameworks that consist of elements required to customize the information collection while maintaining structure across the Web and mobile platforms. In recent years, there has been an explosion of web-based platforms that have enabled creation, storage and provision of information without the traditional authoritative way that required user intervention and formal methods of data collection. These platforms include OSM and Wikimapia, which empower citizens in participating in creating a diverse collection of geographic information. This is done without government regulations and formal training, leading to innovations and discovery of different patterns that are of immense importance to researchers and other players who require access and analysis of such data for different consumption patterns.

It is important to note that the hardware, software and web services associated with VGI are altering the ways in which spatial data may be produced and shared. These new approaches to producing and sharing geographic information, whether through VGI services such as Wikimapia or OSM, are different from the traditional architectures of government-controlled SDIs that require formal dissemination of data with structured quality checks.

3. Client applications and editors

These tools are used to add information on various VGI systems. For instance, long-established editors such as Potlatch or JOSM (Java OpenStreetMap Editor) are preferably used by more advanced members. These may include maps and other navigations on which collected information can be rendered. They can also include web services. Other additional functionalities in the form of widgets would also play a major role in expanding and provisioning for information presentation. They may provide user identification, information validation and user feedback that is anchored to the theme and the users involved in the contribution.

4. Communication protocols

Communication can be defined as the process of sending one piece of information from the sender (encoder) to the receiver (decoder) with the aim of conveying a message. A communication protocol is a rule or a set of rules applied in transiting data from one node of a network to another. For instance, in a VGI platform, data is transmitted from the data layer through the business layer to the presentation layer for processing. This is usually in a layered manner as defined in the OSI reference model. An example of such a protocol is HTTP, which is the foundation protocol for data communication for the World Wide Web and other web services. Thus, these rules will be applied depending on the data being transmitted at different layers and across different components of a VGI platform.

5. SOA, REST and Internet of Services

Representational State Transfer is an architecture for network information and services that relies on a stateless client-server and cacheable communication channel. Internet of Services attributes Web 2.0 technologies with having a decentralized model of delivering different services on the net (Schroth and Janner, 2007). In which case, VGI would have significant applicability especially with the development of spatial marketplaces that would require both data and processing services, providing an interoperability mechanism of passing messages between users.

VII. Chapter Seven

A. Policies on VGI

Geo-information is a double-edged sword regarding its powers in providing instant access to vast amounts of data and the opportunity to abuse, misinform, and invade the privacy of individuals on a greater scale than ever before. On the other hand, the value of geospatial information comes from its use. Therefore, access, sharing and re-use of geospatial information have become essential issues on the arrangement of legal aspects of the domain, particularly those related to public access and ownership of geospatial information and intellectual property rights in geospatial information. Access and sharing of spatial data will ensure the continuation of the enhancement of the quality of geospatial information resources.

1. Enabling legal frameworks: Laws, regulations, acts and policies

While there are many benefits for sharing and exchanging geographic information, and making it available and easily accessible to decision makers and users, dedicated efforts are required to create the environment for it to happen. It requires the development of a specific plan of action, elaborating specific mandates and responsibilities for the data producers or custodians, interoperability standards to ensure that the various data sets can be integrated seamlessly, access rights and restrictions of users, technical components to make it work, legal and regulatory frameworks to enforce the standards, rights and responsibilities, funding resources, partnerships, capacity development and a dedicated governance arrangement to implement and maintain the plan.

Setting up an enabling legal and regulatory environment will foster adoption of appropriate mechanisms for the cooperative production, management, dissemination and use of citizens' generated data and other geospatial information resources at global and national level (National Spatial Data Infrastructures—NSDI) in the continent.

2. Licensing models, Intellectual Property Rights and copyright, liability, security and privacy

Ubiquitous sharing and exchange of geospatial content and services is hampered by the threats of the infringement of the intellectual property of providers and producers (M. Bish and al. 2006).

Determining a party's intellectual property rights in geospatial information and maps is often difficult. For example, there are a number of factors that must be considered in determining whether geospatial information products receive copyright protection, including the type of data, where the data was collected, the type of party (e.g. private company or public entity) exercising the rights and how the data was compiled and published. Moreover, some countries provide additional intellectual property rights in geospatial information contained in databases. The issue becomes increasingly complicated as data from different sources are aggregated, particularly if commercial or individual data from more than one constituency is aggregated. Often these disparate data sets are subject to various licensing regimes, making it difficult to understand the ownership rights in the final geospatial information products.

Currently, there are a number of national and international initiatives underway to develop a single or series of generic data sharing or license agreements for the transfer of geospatial information. For instance, OGC has recently established the GeoDRM working group aimed at facilitating the adoption of Digital Rights Management, as a technology for dissemination and management of intellectual property rights, into the geospatial domain (M. Bish and al. 2006). It is hoped that the adoption of Digital Rights Management technology into the geospatial field will enable the management and licensing of intellectual property rights on geospatial resources.

3. Data security issues / types of vulnerability services

Defence and intelligence agencies often express concerns that the broad availability of geospatial information is a risk to national and homeland security. One of the reasons for such concerns is that geospatial technology was initially the domain of the military and defence communities and was often highly classified. While intelligence and defence agencies are still major consumers of geospatial technology, there has been an explosion of geospatial-enabled applications for uses in civilian agencies and the commercial sector. However, the defence and intelligence communities continue to view geospatial information through a national security and homeland security prism. Moreover, the duality of geospatial information also raises a number of concerns. For example, the same information that can be used to identify government buildings for evacuation during an emergency can also be used by terrorists to identify potential targets.

A geospatial information management legal and regulatory framework needs to weigh the perceived national security risks with the growing economic and societal benefits associated with geospatial technology. While such benefits are difficult to quantify at this time, the potential for geospatial technology is becoming increasingly clear. While national security risks cannot be discounted, and will vary among nations, research suggests that procedures can be put in place to address such concerns.

4. Linkages with National SDI

An infrastructure approach with institutional, regulatory and technical arrangements is required to coordinate the production, management and dissemination of geospatial information content in a manner that ensures that decision makers, and the population at large, have access to such information when they need, where they need it, and in a form they can use easily. Therefore, a review of policies and institutions developed in connection with NSDI can provide useful tips with regards to the laws and regulations necessary for the collection and sharing of citizen-generated location data.

NSDIs enable the provision of, and access to, essential spatial data and information essential to social and economic development in modern societies. They are a robust response to the challenges that governments and societies confront in the use of spatial data and its transformation into information and knowledge that are needed for decision-making.

Within NSDI, a legal and regulatory framework to support volunteer geographic information can be developed and maintained through a four-phase approach. Such an approach has two primary benefits. First, it allows for a government to identify and address the most pressing legal and regulatory issues that impact the collection, use, distribution and management of location data. Second, each phase can be modified as issues arise in the previous phase.

Phase 1: The purpose of the initial phase would be to (a) develop a baseline assessment of the existing legal and regulatory framework with respect to matters that impact geospatial information management; and (b) identify challenges that are unique to the country. This phase would begin with a thorough review of applicable laws, cases, regulations, policies, etc. that relate directly to geospatial information management and other legal issues that could indirectly impact the collection, use and transfer of geospatial information. For example, Phase 1 would include a review of laws and regulations related to mapping and cartography, remote sensing, geodesy and land management in addition to intellectual property rights, privacy, national security and product liability. It would be followed by extensive interviews with (a) government officials, industry, academia and the broader geospatial community; (b) geospatial technical experts; and (c) lawyers, policymakers and lawmakers. Prior to the interviews, each person would receive a questionnaire on the impact that legal and regulatory issues have on geospatial information management in that country. Finally, a written report and oral presentation of the findings could be delivered to members of a committee of stakeholders.

Phase 2: The purpose of the second phase would be to identify gaps between the existing legal and regulatory environment and best practices from around the world. It would consist of a review of best practices around the world with respect to geospatial information management, with particular focus on nations with comparable legal systems and cultural and societal norms. A gap analysis would be prepared to address (a) specific laws and policies to be prepared; (b) cultural issues impacting geospatial information management; and (c) any capacity needs from a legal and regulatory standpoint (e.g. training of lawyers).

Phase 3: The third phase would involve the most substantive work. It would consist of a number of separate but related components. One component would be the preparation of draft laws, policies, regulations, contracts and agreements to address the identified gaps. These drafts would be delivered to key stakeholders for review and consultation. After modification and approval, the drafts could be submitted to appropriate authorities and organizations for adoption and use. The second component would be developing courses and training materials on legal and regulatory matters for stakeholders and their legal and regulatory advisors. The third component would be developing a community of individuals within the stakeholders who are interested in or impacted by legal and regulatory matters.

Phase 4: The fourth phase would be an ongoing effort to assess improvements in geospatial information management and to identify new legal and regulatory challenges as they arise or as the uses of geospatial information evolve. One method to assess such improvements would be to conduct government-wide geospatial information audits to identify any unforeseen or new legal and regulatory issues. Such audits would involve interviews of government officials, industry and the NGO community as well as reviews of laws, regulations and a sample of data sharing agreements.

VIII. Chapter Eight

A. Ingestion and adoption of VGI by African NMAs

Area	Policy principles	Strategic actions
Building blocks for leveraging VGI	National mapping organizations (NMA) are responsible for providing the majority of the fundamental geospatial data sets. They are the authoritative source for these data sets. This means that the data sets must be trusted.	To be trusted strategic actions must be taken for the data set to meet the following requirements: • Positional accuracy • Semantic accuracy • Attribute accuracy • Completeness • Consistency • Currency
Changes to business logics and technology progress within NMAs	NMAs are challenged to ensure that their geospatial data sets are trusted. In Africa, the situation is dire. Most of Africa is poorly mapped, and even what does exist is out of date. NMAs are under-resourced, lack modern technology and lack political support for national mapping programmes. This does not mean that they do not have a function to perform. On the contrary, since authoritative fundamental geospatial data sets are essential for meaningful development, NMAs need to be re-energized and to find innovative ways of achieving their mandates.	Generating more geospatial information through VGI.
Capacities development	The geo-spatial information acquired through VGI does not meet the requirements for an authoritative fundamental geo-spatial data set	Capacity development in VGI is required
Challenges and opportunities	**Challenges** VGI must be tested for: • Positional accuracy • Semantic accuracy • Attribute accuracy • Completeness • Consistency **Currency** Findings on OpenStreetMap data: • Does not meet positional accuracy standards of NMAs. -In urban areas accuracy is good	Currently VGI cannot be adequately integrated with the data of NMAs and strategic actions are required for the integration process. VGI can be exploited by NMAs in their national mapping programmes

	• Completeness is high in urban areas, in particular commercial areas, although some bias can be evidenced • Completeness is not high in peri-urban areas and worse in rural areas (non-existent in many areas) • Semantic accuracy is high for ‘street’ category but lesser for other road types • Integration of OSM data into national mapping database is complicated, mainly due to such large variations in accuracy and completeness **Opportunities** Some ways in which VGI can be used by NMAs: • Change alerts (detection) – improving currency, in particular of major features • Reporting of errors • Geographical names • Opportunity of engagement with public – awareness raising. By either: Subscribing to common VGIs operating own VGI system – including verification processes • Open-source tools	
Guiding principles	• Positional accuracy • Semantic accuracy • Attribute accuracy • Completeness • Consistency • Currency • Interoperability • Open data format • VGI data dissemination	

Source: Expert Group Meeting on Volunteered Geographic Information (VGI) Regional Centre for Mapping of Resources for Development (RCMRD), Nairobi Kenya, 21-22 November 2015.

B. VGI guiding principles, legal and policy issues related to VGI

		Opportunity	Constraints	Remarks
VGI guiding principles, legal and policy issues related to VGI	Step-by-step VGI guiding principles that can be implemented as a best practice	**Custodian** • Data to be moderated before publishing • Ensure anonymity option to contributor • Non-disclosure of personal data of contributor • Open data principle applies • Creative commons licence applies to data • Code of conduct applies to data **Contributor** • Code of conduct applies to contribution **Users** • Subject to user licence		Incentivize contributors e.g. no data communication charges when contributing
	Legal issues that hinder effective implementation of VGI in Africa		• National security policies and laws • IP laws and policies • Lack/ restrictive regulation of data collection methods e.g. Use of UAV	
	Policy options present to effectively harness the potentials of VGI in Africa	• Open data supported by government • Promotion of access to information • Promotion of open standards and FOSS • Integration of VGI into NSDI		

Source: Expert Group Meeting on Volunteered Geographic Information (VGI) Regional Centre for Mapping of Resources for Development, Nairobi Kenya, 21-22 November 2015.

IX. Chapter Nine

A. Issues and challenges

1. VGI-SDI integration

Due to the platforms and technologies used, there is a challenge in integrating data from the authoritative SDIs that use more authoritative geoportals and different kinds of infrastructure compared to the VGI framework. This is also due to the fact that the time it takes to correct government-sanctioned data is also long and tedious and may be outdated by the time of its release. Hence, integration and working with data from the two sources becomes difficult.

The fact that users are not trained and are voluntarily providing data indicates that there is a challenge posed in understanding VGI quality, integrity and credibility. Therefore, for VGI to be authoritative, there are dangers in terms of data quality, integrity and quality evaluation tools that would be needed to eliminate any such doubts. Any questions regarding the contributor and the source of such data sets need to be answered. Methods to compute credibility of such data need to be identified and applied systematically. From the perspective of public authorities, the main challenge to using VGI is the lack of managerial control over the lineage of the information leading to unknown reliability and trustworthiness (Jennex, 2010).

2. Data accuracy

This aspect in VGI may lead to more confident decision-making and this can mean greater operational efficiency. However, due to the fact that the nature of crowdsourced data should attain some level of acceptable accuracy poses a major challenge. Subsequently, other computational tools and/or mechanisms are needed in order to validate such data.

3. Broadband Internet must be available

In many countries, VGI data is more pronounced in urban areas than rural areas. This is because broadband data communication is not available in most of the rural areas and it is key in VGI data collection and provision. This may lead to imbalances in crowdsourced data leading to disparities. The development or programming language in which VGI frameworks are developed could further complicate issues based on the fact that many VGI services only support the Roman alphabet in the English language. This is a hindrance to users of other alphabets that would like to access VGI platforms that are designed in Roman alphabet only.

4. Lack of reference data sets in some countries

Hence, in such cases, new methods that utilize multiple VGI data sets need to be included. There is also the lack of metadata for the VGI system. This makes it difficult for users to discover data in the VGI system (Kalantari, Rajabifard, Olfat, and Williamson, 2014).

5. Information privacy

Players in VGI systems are sometimes uncomfortable in terms of data being shared, stored or transferred. This poses a major challenge in the collection of data that may also be influenced by cultural reservations. There are assumptions that crowdsourced data would fill the existing gaps. As much as the traditional and authoritative spatial data collection methods have their limitations, getting the crowdsourced users fully involved especially in the storage and updates of data may be challenging. This could be due to lack of interest or the lack of knowledge in the area under consideration.

B. The challenges of involving end users

The collection of crowdsourced data may not involve any formal training of end users to get out the community and consult them regarding their expectations on the geospatial platform and this may pose a challenge. The challenge of how to maintain the contributors interested and active in the continuation of the effort needs also to be addressed (Coleman, Georgiadou et al. 2009). The volume of relevant content—due to the large amount of content that is shared and exchanged through VGI—becomes a challenge to identify, retrieve process and analyse the actual relevant content associated with a certain theme in question. Spinsanti and Ostermann (2013) suggest that the novelty of the approach to be undertaken, for instance, in times of crisis, lies in the enrichment of the content with additional geographic context information, and use of spatio-temporal clustering to support scoring and validation.

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